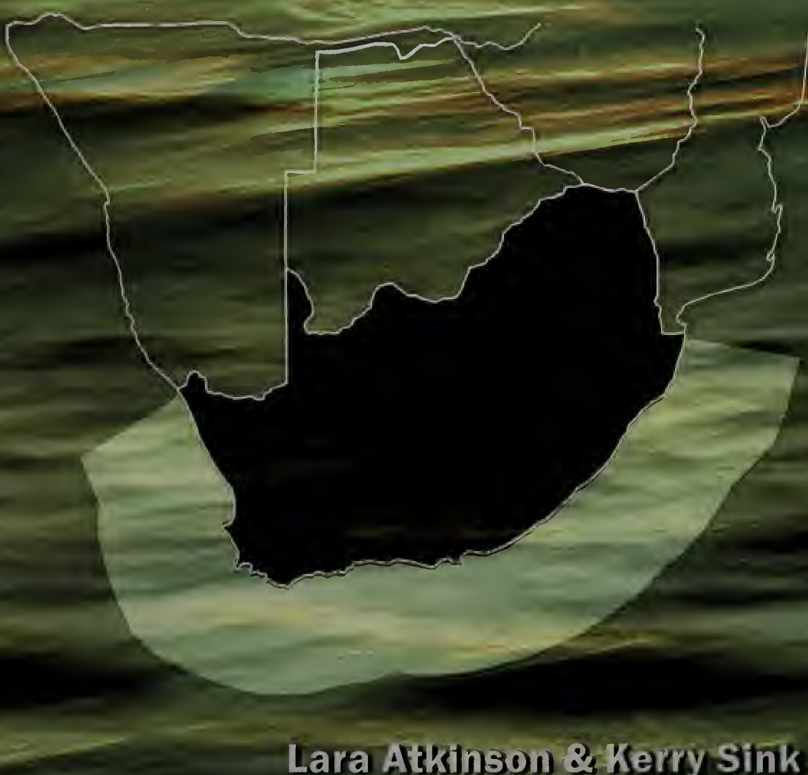
User profiles for the South African offshore environment



Lara Atkinson & Kerry Sink

2008
SANBI
Biodiversity Series

10

SANBI Biodiversity Series 10

User profiles for the South African offshore environment

Lara Atkinson

Kerry Sink

SOUTH AFRICAN national biodiversity institute SANBI

Pretoria

2008

SANBI Biodiversity Series

The South African National Biodiversity Institute (SANBI) was established on 1 September 2004 through the signing into force of the National Environmental Management: Biodiversity Act (NEMBA) No.10 of 2004 by President Thabo Mbeki. The Act expands the mandate of the former National Botanical Institute to include responsibilities relating to the full diversity of South Africa's fauna and flora, and builds on the internationally respected programmes in conservation, research, education and visitor services developed by the National Botanical Institute and its predecessors over the past century.

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SANBI's mission is to champion the exploration, conservation, sustainable use, appreciation and enjoyment of South Africa's exceptionally rich biodiversity for all people.

SANBI Biodiversity Series will publish occasional reports on projects, technologies, workshops, symposia and other activities initiated by or executed in partnership with SANBI.

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Authors' addresses:
Ms L. Atkinson, Marine Research Institute, University of Cape Town, Private Bag X3, 7701 Rondebosch, Cape Town.
Dr Kerry Sink, WWF Offshore Biodiversity Initiative, South African National Biodiversity Institute, Private Bag X7, Claremont 7735, Cape Town.

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For copies of this document or further information, please contact:
South African National Biodiversity Institute
Marine Project Manager
Private Bag x7, Claremont, 7735 Cape Town
Tel: +27 21 799 8855
sink@sanbi.org
www.sanbi.org

Acronyms

BOP	Blowout prevention
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CEF	Central Energy Fund
CL	Carapace length
CNRI	Canadian Natural Resources International
CPUE	Catch per unit effort
CSIR	Council for Scientific and Industrial Research
DBCM	De Beers Consolidated Mines
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
EASSY	East African Submarine Cable System
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
EMPR	Environmental Management Programme Report
EMS	Environmental Management System
GDP	Gross domestic product
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICSEAF	International Commission for the Southeast Atlantic Fisheries
IHO	International Hydrographic Organization

IMO	International Maritime Organization
IOTC	Indian Ocean Tuna Commission
IUCN	International Union for the Conservation of Nature and Natural Resources
KZN	KwaZulu-Natal
LMP	Line fish Management Protocol
MCM	Marine and Coastal Management
MDMA	Marine Diamond Mines Association
MENZ	Ministry of the Environment of New Zealand
MLRA	Marine Living Resources Act No. 747 of 1998
MPA	Marine Protected Area
MPRDA	Mineral and Petroleum Resources Development Act No. 28 of 2002
NEMA	National Environmental Management Act No. 107 of 1998
OMPA	Offshore Marine Protected Area
OPASA	Offshore Petroleum Association of South Africa
OPRC	International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990
ORI	Oceanographic Research Institute
PASA	Petroleum Agency South Africa/South African Agency for Promotion of Petroleum Exploration and Exploitation
PMCL	Precautionary maximum catch limit
RFMOs	Regional Fisheries Management Organizations
SADSTIA	South African Deep-Sea Trawling Industry Association
SAFE	South Africa/Far East cable
SAMSA	South African Maritime Safety Authority
SAN	South African Navy
SANBI	South African National Biodiversity Institute
SANHO	South African National Hydrographic Office
SECIFA	South East Coast Inshore Fishing Association
SOEKOR	Southern Oil Exploration Corporation
TAC	Total allowable catch
TAE	Total applied effort
VMS	Vessel monitoring systems
WASC	West African Submarine Cable
WSSD	World Summit on Sustainable Development

Introduction

Approximately 9 % of South Africa's coastline is afforded full protection in the form of Marine Protected Areas (MPAs), with an additional 14 % having some lesser degree of protection (limited utilization). In terms of South Africa's Exclusive Economic Zone (EEZ), only 0.16 % of the total area has full marine protection. The offshore marine environment has considerable economic, social and scientific importance with offshore biodiversity providing many essential goods and services and is the source of several important commercial fisheries in South Africa (Sink & Attwood 2007). Globally, extractive offshore activities (e.g. fishing and mining) and non-extractive offshore activities (e.g. shipping, undersea cables, naval activities) are known to have long-term impacts on ecosystem health and biodiversity with concomitant social and economic costs (Olsgard & Gray 1995; Goñi 1998; Jennings & Kaiser 1998; Watling & Norse 1998; Gislason *et al.* 2000; Kaiser *et al.* 2003; Kaiser *et al.* 2006; Queiros *et al.* 2006). Representative MPA networks have been identified as a critical component in conserving offshore biodiversity and promoting sustainable marine resource use (Sink & Attwood 2007). Through the ratification of several international conventions and agreements (e.g. Convention on Biological Diversity 1992; World Summit on Sustainable Development 2002; World Parks Congress 2003) and local legislation or policies, South Africa has pledged commitment to protect marine biodiversity, ecological integrity and promote sustainable use of marine resources. As such, South Africa has committed to implementing an ecosystem approach to marine resource management and the establishment of a representative marine protected area network by 2012. Global targets recommend that 10–30 % of each marine habitat type should be incorporated into effectively managed marine and coastal protected areas by 2012. The Offshore Marine Protected Area Project (OMPA), housed within the South African National Biodiversity Institute (SANBI) Marine Programme, aims to identify a potential offshore MPA network that will contribute towards South Africa's commitments in this regard. This project is the first of its kind to undertake co-operative consultation with several government departments and many stakeholders, representing commercial fishing, mining, petroleum and other maritime industries that utilize South Africa's offshore marine areas.

This document aims to provide background information on the various offshore marine resource users (extractive and non-extractive), operating within South Africa's EEZ. An overview of the history, general operation and area of the activity is provided. Known and potential biodiversity impacts as a result of the activity, overlap and issues of conflict between various resource users are identified. Information provided in this document was deemed current as of August 2007.

CHAPTER 1

Petroleum activities

Overview

Exploration for oil in South Africa began as early as 1946 in the Karoo Basin. In 1965, the parastatal Southern Oil Exploration Corporation (SOEKOR) was established and began offshore exploration with the intention to search for, and if found, commercially exploit viable oil and gas deposits, both independently or in partnership with foreign companies. From the mid 1970s until the late 1980s, SOEKOR was the sole explorer operating the entire offshore area of South Africa. This was largely due to political sanctions at that time. In 1994, offshore areas were opened to international investors via a new licensing round. In 1999, SOEKOR was re-constituted as the South African Agency for Promotion of Petroleum Exploration and Exploitation—Petroleum Agency SA (PASA) (www.petroleumagencysa.com, May 2007). It is a subsidiary of the Central Energy Fund [CEF (Pty) Ltd] and has the mandate to ensure optimal development of the natural oil and gas potential of the Republic of South Africa. PetroSA, also a subsidiary of CEF (Pty) Ltd, owns and manages the South African government's commercial assets in the petroleum industry, including exploration, production on the south coast and international upstream petroleum ventures (PASA 2007). The petroleum industry is highly competitive and internationally governments are prioritizing petroleum development and creating incentives for gas exploration, stimulating petroleum exploration activities in the EEZ of those countries [Ministry of the Environment of New Zealand (MENZ) 2005]. South Africa is also actively aiming to expand oil and gas production within the EEZ and the PASA is leading the extended continental shelf claim that, if awarded, would increase the size of South Africa's EEZ and thus provide access to hydrocarbon resources.

The following description of exploration activities is drawn mostly from a Generic Environmental Management Programme Report prepared by Crowther Campbell & Associates and Centre for Marine Studies (CCA & CMS 2001). Offshore hydrocarbon exploration involves gravity, magnetic and two- or three-dimensional seismic surveys to investigate subsea geological formations. High level, low frequency sounds are directed towards the seabed from near-surface sound sources towed by a ship and reflected signals from geological discontinuities below the sea floor are recorded by towed hydrophones. The data gained from seismic surveys are used to identify potential hydrocarbon traps. Prospect wells are drilled to test these potential accumulations of oil and/or gas. Over 300 wells have been drilled within the South African EEZ and some 233 000 line kms of two-dimensional and 10 200 km^2 of three-dimensional seismic data have been acquired (PASA 2007). Various types of drilling platforms are used around the world in offshore drilling for petroleum. These include barges in shallow waters, platforms fixed to the seabed at depths of up to 300 m, semi-submersibles and drill ships for deep-water drilling (Figure 1.1). A typical drilling procedure involves the use of equipment such as a derrick (supporting the equipment used to raise and lower the drill string), drawworks, drilling mud, handling equipment, power generators, cementing and testing equipment and a blowout prevention (BOP) unit. An array of six to eight anchors (12 to 20 tons each) are used to position and hold the drilling unit in place. Drilling generally crushes rock into finer particles termed 'cuttings'. The cuttings are removed from the bottom of the hole in a drilling fluid or 'mud', a mixture of natural clays, polymers, weighting agents and other materials, suspended in a fluid medium. Guide bases (steel structures 3.5 m wide and 4.7 m high) are used to position the drill accurately. Figure 1.2 illustrates key steps in the drilling process.

Before reliable technology was available, the temporary and permanent guide bases were 'abandoned' on the sea floor if no commercial oil or gas was found or the well was deemed unsuitable for further use (CCA & CMS 2001; Figure 1.3). These wells were then sealed off with cement plugs to prevent hydrocarbons escaping to the surface and also to prevent contamination of aquifers. In the South African offshore region, 143 wells (2007 Notice to Mariners) have been left in this 'abandoned' condition. If further use of the well is planned, it is 'suspended' to allow for re-entry, and the guide bases are left on the sea floor but a corrosion cap is usually placed over the

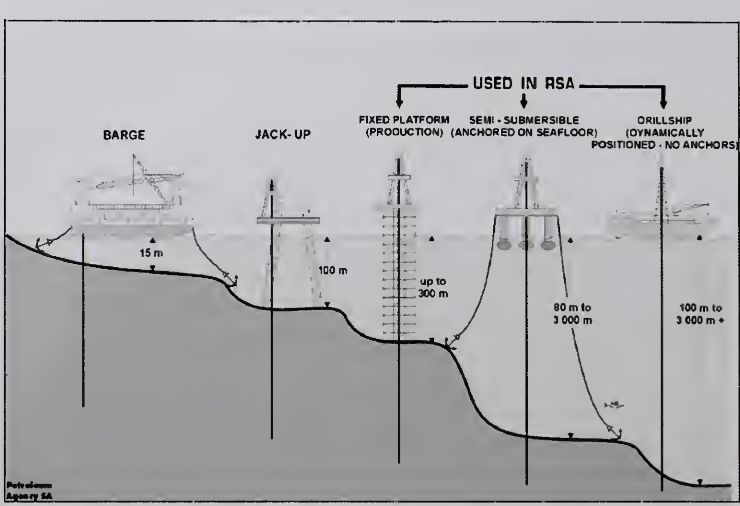

FIGURE 1.1.—Diagram of different types of drilling platforms (from CCA & CMS 2001).

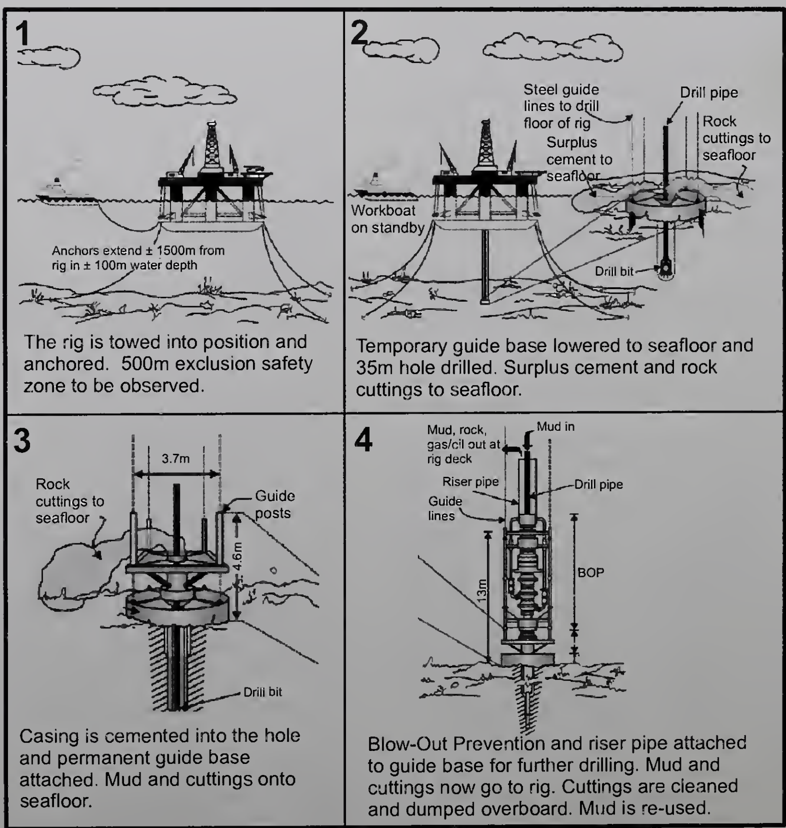

FIGURE 1.2.—Diagrammatic representation of key steps in drilling (from CCA & CMS 2001).

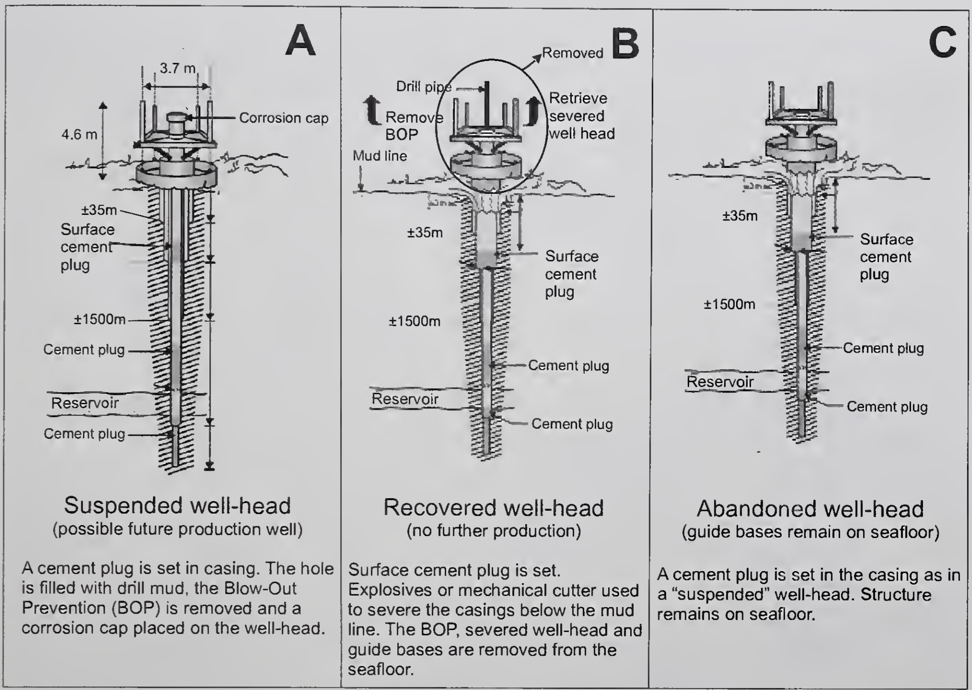

FIGURE 1.3.—Diagrammatic representation of well heads no longer in use (from CCA & CMS 2001).

well head. Recent practice in South African prospecting work (post 1999) is to retrieve the guide bases, leaving only a 2.5 m long casing protruding above the sea floor (CCA & CMS 2001). Recovering well heads involves the removal of the 30 and 20 inch casings about 3 m below the sea floor and the removal of the guide bases, leaving a small hole in the sea floor. The equipment removed is recycled or disposed of on land.

Where development of oil and gas activities takes place, offshore production platforms are installed and subsea well head structures and pipelines (including flowlines, umbilicals and risers) may be installed (Blood & Corbett 2006). Platforms contain the equipment used for production and initial processing and can include an accommodation area with living quarters and associated utilities. Onshore production pipelines are sometimes installed to transport gas to onshore processing facilities.

Oil and gas have been discovered within several parts of South Africa's EEZ (Figure 1.4) with most wells drilled in less than 250 m water (I. McLachlan pers. comm.). The Bredasdorp Basin on the Agulhas Bank has been the focus of most seismic and drilling activity. Commercial production has taken place on the Agulhas Bank with the development of the Oribi, Oryx and Sable oil fields. The Orca is a floating oil production facility that supplies a crude oil refinery in Cape Town via a shuttle tanker. The FA gas fields and satellites are situated about 90 km offshore of Mossel Bay. They produce gas condensates which are transported by pipeline to PetroSA's production facility at Mossel Bay where petrol, diesel and kerosene are produced (PASA 2007). During 2006, average production from these fields was approximately 3 900 barrels of oil per day and 160 million standard cubic feet of gas per day (PASA 2007). There are several operators evaluating oil and gas potential on the west coast and the Ibhubesi Gas Field is currently being appraised for development (www.petroleumagencysa.com, May 2007). The development of the Ibhubesi Gas Field would entail an offshore subsea development scheme with onshore production (processing and compression) facilities. Over the four development phases it is anticipated that 99 wells would be drilled in License Block 2A in the 200–250 m depth range (Blood & Corbett 2006) although the deepest planned well in the west coast region is in excess of 1 000 m (I. McLachlan pers. comm.). International operations frequently exploit oil at depths of ~3 000 m and deeper, but such large-scale operations are costly. South Africa is currently holding a new licens-

PETROLEUM EXPLORATION & PRODUCTION ACTIVITIES

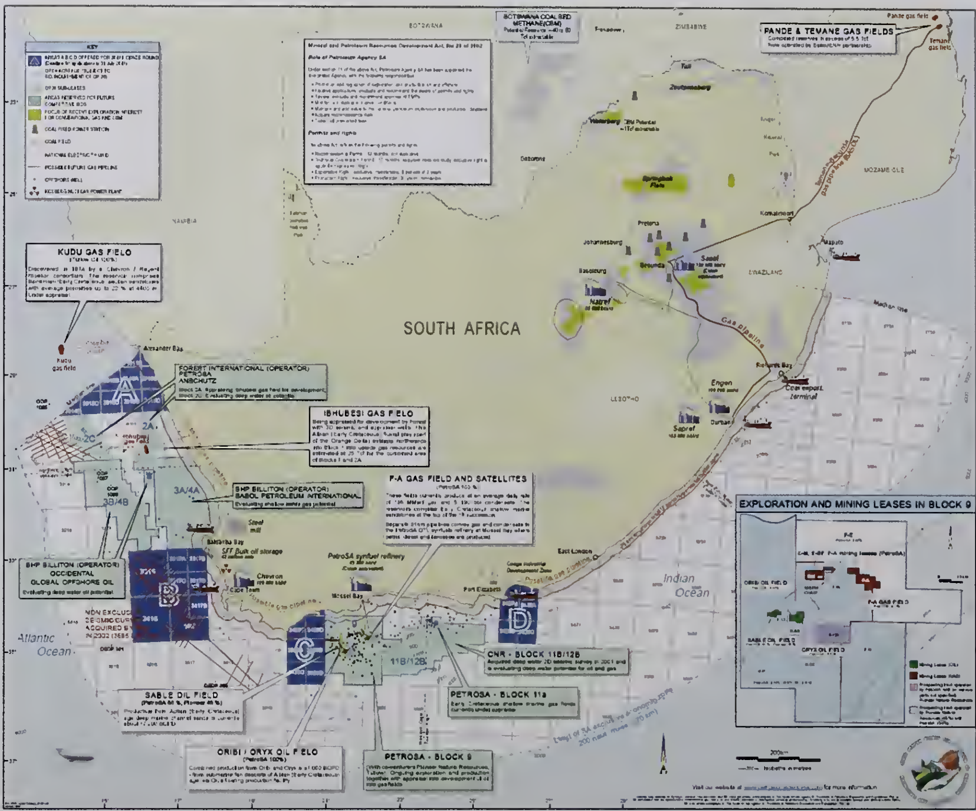

FIGURE 1.4.—Offshore oil and gas exploration and license blocks in South Africa's Exclusive Economic Zone (source: www.petroleumagencysa.com).

ing round with new acreage on offer in shallow water in the northern Orange Basin, the shelf and deep water in the southern Orange basin, the western part of the Bredasdorp Basin and offshore of the Algoa Basin (PASA 2007). The aim of offering new acreage is to increase South Africa's oil and gas production through a competitive bid process. The Orange Basin is considered under-explored and is believed to have significant potential for gas on the shelf and for oil in deeper water (PASA 2007). Limited seismic and drilling exploration (four wells) has occurred on the east coast, but preliminary data is reported to justify further exploration. An area of the Tugela Basin off the KwaZulu-Natal north coast has aroused substantial interest for oil exploration as there appears to be evidence that this area has untapped natural oil resources. A United States oil company (Global Offshore Oil Exploration) was legally embattled with the South African Agency for the Promotion of Petroleum Exploration (PASA) for rights to explore the area off KwaZulu-Natal for oil and natural gas (www.ports.co.za, May 2007). In November 2006 the case was dismissed and the scope for oil exploration in this region is now open to both local and international interests.

Current license holders (Block 9 and 11A) include:

- PetroSA (Pty) Ltd
- Energy Africa
- Pioneer Natural Resources (South Africa) (Pty) Ltd

Current subleases (prospecting) are held by:

- Anschutz (South Africa) (Pty) Ltd—Blocks 1, 2A and 2C
- Forest Exploration International (Pty) Ltd—Blocks 1, 2A and 2C
- Pioneer Natural Resources (South Africa) (Pty) Ltd—Block 14B
- Canadian Natural Resources International (CNRI) (South Africa)—Blocks 11B and 12B
- BHP Billiton Petroleum Ltd--Block 3B/4B
- Sasol Petroleum International (Pty) Ltd—Block 3A/4A (Source: www.petroleumagencysa.com, May 2007)

Value

Offshore production of oil and gas (which is converted to liquid fuel at Mossgas) fulfills ~ 7 % of South Africa's oil requirement (I. McLachlan pers. comm.). Approximately 69 % of South Africa's crude oil requirements are imported from elsewhere, with the balance (~ 24 %) being obtained from coal, using Sasol's synthol process (PASA 2007).

The proposed development of the Ibhubesi Gas Field may have the potential to make a macro-economic impact on South Africa in general (in terms of Gross domestic product—GDP) and on the relevant geographical regions specifically (Blood & Corbett 2006). An economic specialist study will be commissioned to assess this potential impact (Blood & Corbett 2006).

Governance framework

Energy interests in South Africa are administered by the Department of Minerals and Energy (DME). Under South African law, DME is responsible for ensuring correct environmental management of oil and gas prospecting and production activities. The South African Agency for Promotion of Petroleum Exploration and Exploitation (PASA) is, however, the designated agency with the responsibility for promoting, licensing, monitoring and data archiving of the petroleum exploration and production industry in South Africa. PASA is considered to be a region within the DEM structure. In carrying out its responsibilities, the PASA consults with the Department of Environmental Affairs and Tourism (DEAT) and other relevant government departments (CCA & CMS 2001). The most important item of legislation with respect to oil and gas exploration activities is the Mineral and Petroleum Resources Development Act No. 28 of 2002 (MPRDA) which was promulgated in 2004, replacing the Minerals Act No. 50 of 1991. The MPRDA, *inter alia*, regulates the prospecting for and optimal exploitation, processing and utilization of minerals, and controls the rehabilitation of land disturbed by exploration and mining (Robinson *et al*. 2006). The PASA is appointed as the designated authority under section 71 of the MPRDA for administration of governance relating to the petroleum industry. Four types of petroleum rights can be issued in terms of the MPRDA:

- a reconnaissance permit: valid for one year
- a technical co-operation permit: valid for one year
- an exploration right: available for three periods of two years each
- a production right: available for 30 years

In terms of the MPRDA, an operator is required to prepare an Environmental Management Programme Report (EMPR) prior to the commencement of exploration activities. A generic EMPR for all South African offshore petroleum activities was prepared in 2001 and serves as a reference for exploration applications (CCA & CMS 2001). Development and production operations require their own specific EMPRs. The MRPDA specifies that production rights must be approved prior to commencement of development activities. A requirement for obtaining a production right is that an Environmental Management Programme (EMP) for the operation must be compiled and submitted to the PASA for approval. As part of the compilation of the EMP, an Environmental Impact Assessment (EIA) must be conducted in terms of Section 83(4)(b) of the MPRDA.

National legislation pertaining to the International Maritime Organization (IMO) stipulates that an exclusion zone of 500 m should be observed by all vessels in the vicinity of an operational oil rig. Trawl vessels, in particular, are requested to observe anchor chains and anchors, that can extend more than 1 500 m from the oil rig, posing hazards to fishing operations.

Prior to the commencement of drilling activities, the operators must consult with relevant bodies including the Department of Minerals and Energy (DME), PASA, the South African Maritime Safety Authority (SAMSA), the South African Navy Hydrographic Office, relevant port captains, the South African Deep-Sea Trawling Industry Association (SADSTIA), the South East Coast Inshore Fishing Association (SECIFA) and Marine and Coastal Management, DEAT. These bodies must be notified of the navigational co-ordinates of any new location, prior to any drilling activities.

The Offshore Petroleum Association of South Africa (OPASA) includes several petroleum companies who work co-operatively in some instances. This association is the appropriate body for general communication with the South African petroleum sector.
Other relevant legislation:

- Atmospheric Pollution Prevention Act No. 45 of 1965
- Dumping at Sea Control Act No. 73 of 1980
- Environmental Conservation Act No. 73 of 1989
- Marine Traffic Act No. 2 of 1981

- Marine Living Resources Act No. 18 of 1998
- Marine Pollution Control and Civil Liability Act No. 6 of 1981
- Marine Pollution Prevention of Pollution from Ships Act No. 2 of 1986
- Maritime Safety Authority Act No. 5 of 1998
- Maritime Zones Act No. 15 of 1994
- Merchant Shipping Act No. 57 of 1951
- National Environmental Management Act No. 107 of 1998
- National Heritage Resources Act No. 25 of 1999
- National Parks Act No. 57 of 1976
- National Nuclear Energy Regulator Act No. 47 of 1999
- Nuclear Energy Act No. 46 of 1999
- Sea-Shore Act No. 21 of 1935
- Sea Birds and Seals Protection Act No. 46 of 1973

Biodiversity impacts

Marine seismic surveys can have short-term adverse effects on some marine life (MENZ 2005). The potential impacts of seismic surveys on plankton, invertebrates, fish, turtles, sea birds and marine mammals in South African waters have been assessed (CCA & CMS 2001). Potential impacts on penguins, turtles and cetaceans were rated of medium to high significance in certain areas and seasons, whereas potential impacts on the other marine species were considered to be negligible or low (CCA & CMS 2001). The fishing industry has expressed concerns that seismic activity may affect fish behaviour, distribution and/or changes in fish catches. No quantitative data or evidence thereof is currently available. The impact that petroleum exploration seismic surveys have on baleen whales is of some concern (Gründlingh *et al.* 2006). Baleen whales are known to have good low-frequency hearing which overlaps with the output range of frequencies used for seismic surveys. There is a strong likelihood that the frequency emissions of seismic surveys will negatively impact on whales in the vicinity. The mitigation measure currently employed is to avoid seismic surveying when whales are likely to be present (Gründlingh *et al.* 2006).

Discharge of drilling muds and cuttings have a potentially adverse impact on the environment (Gründlingh *et al.* 2006). Cuttings are discharged overboard throughout the drilling operation and surplus mud is discharged on completion of the well (Gründlingh *et al.* 2006). The impact 'footprint' of these discharges is of concern to benthic biodiversity. Fossil water, trapped within oil-bearing rock has been known to rise to the surface during oil extraction. This 'produced water' is usually the largest aqueous discharge from offshore production platforms and can reach volumes of up to 20 000 m^3 per day (Sakhalin-I 1994 in Gründlingh *et al.* 2006). Limited research has been conducted on the properties of produced water. It is likely to contain chemicals which could have adverse effects on marine biota, particularly larval stages (Gründlingh *et al.* 2006).

The impact of petroleum activities has not been examined in South Africa but international studies have shown that offshore drilling can result in the following impacts:

- contamination of the marine environment through drilling muds (Cranmer 1988; Neff *et al.* 1987, 1989; Davies & Kingston 1992; Hyland *et al.* 1994; Olsgard & Gray 1995; Daan & Mulder 1996; Cranford *et al.* 1999). Contamination effects are linked to increased total hydrocarbons, barium, strontium and metals such as zinc, copper, cadmium and lead. In Norway, studies showed that ecologically important prey species (brittle stars) for commercially important fish species (e.g. cod), were reduced by initial pollution impacts and replaced by smaller opportunistic species, believed to be less valuable as a food source. Water-based drilling muds have reduced environmental contamination and biological impact less than oil-based drilling muds (Olsgard & Gray 1995);
- disturbance of sediments, habitats and benthic macrofauna by displacement, burial, smothering and sedimentation (Newell 1998; Hyland *et al.* 1994; Olsgard & Gray 1995, MENZ 2005). These disturbances may impact on other species that are dependant upon such fauna as prey items;
- localized disturbance of the sea floor by the anchor chain and the anchors will have negative effects on benthic communities (CCA & CMS 2001);
- associated construction activities such as blasting and pile driving can cause localized damage to marine life;
- potential contamination of the marine environment through waste discharges and oil spills;

- other operational activities such as lighting, helicopter operations and flaring could also impact on marine life (Blood & Corbett 2006);
- physical structures on the seabed can potentially increase the diversity of environments available for benthic organisms, aggregate fish and consequently the biodiversity in the area (Hall 2001).

Pollution and disturbance can impact on both hard-bottom fauna and benthic infauna from unconsolidated (soft substrate) habitats (Daan *et al.* 1992, 1994; Hyland *et al.* 1994). On deep reef habitats, Hyland *et al.* (1994) found that the abundance of some invertebrate taxa (4 of 22) were significantly reduced at sites of heavy petroleum activity. Analyses of chemical contaminants showed concentrations to be below toxic levels and the observed impacts were thus believed to be linked to physical impacts of increased sedimentation such as disruption of feeding or respiration and burial of settled larvae. Most studies show that drilling impacts are relatively localized (Ferbrache 1983; Daan *et al.* 1992; CSIR 1995) but impacts can spread to more than 6 km from platforms (Olsgard & Gray 1995). Petroleum activities at George's Bank on the American east coast were considered to have minimal, if any, impacts on benthic infauna communities compared to the more extensive impacts at mid-Atlantic rig sites (Neff *et al.* 1989). The lower impact was believed to be attributed to the higher energy environment and the lesser accumulations of drilling mud cuttings and solids at George's Bank.

Impacts of petroleum activities should be assessed in South Africa and in areas where petroleum activities overlap with fisheries, particularly on the Agulhas Bank. There is an urgent need for information about the potential cumulative impacts of all oil and gas activities in concert with the impacts of fisheries, in particular that of bottom trawling. Oil and gas structures, particularly on the Agulhas Bank, have prevented demersal trawling and the petroleum sector motivates that this protection may benefit both biodiversity and fisheries (Hall 2001; Love *et al.* 2005). Elsewhere, oil and gas infrastructure has been colonized by reef biota representing a different type of biodiversity from unconsolidated habitats where drilling usually takes place (Forteath *et al.* 1982). Petroleum infrastructure can therefore serve as an artificial reef, increasing biodiversity by providing hard substrate; however, the value of this is controversial. Where cold water coral communities have been heavily impacted by bottom trawling, untrawled artificial reefs may provide habitat for healthy coral colonies (Hall 2001). In California, oil and gas infrastructures were shown to provide habitat for commercially important fishes such as rockfish and lingcod, some of which are overexploited (Love *et al.* 2005). Most MPAs exclude petroleum activities but there are cases where petroleum activities continue in MPAs, where these activities were initiated prior to proclamation (*MPA News* 2004). The Energy & Biodiversity Initiative, a global group developing and promoting best practices for integrating biodiversity with oil and gas development, recommend that the risk of damage should not prevent biodiversity planners and the petroleum industry from exploring ways to work together (www.ebi.org, May 2007). There are cases of co-operative research and management where petroleum activities occur within or adjacent to MPAs.

The greatest environmental concern in exploratory drilling is the probability of an uncontrolled release of hydrocarbons (called a blowout). The probability of this occurring is, however, low, although the environmental consequences of oil spills are severe and gas blowouts have significant safety considerations. The possibility of an oil spill is perceived as the greatest threat posed by this industry to marine biodiversity (Attwood *et al.* 2000). There are no known published studies on the actual physical impacts of oil and gas exploration and development activities in South Africa. Several studies have assessed the impact of oil spills under different spill volume scenarios using OILMAP, a numerical oil spill trajectory model (CSIR 1995; Crowther Campbell & Associates & CSIR 1998). The environmental impact thereof would be considered high; however, the likelihood of occurrence is considered low.

Issues of conflict

There is significant potential for conflict between the offshore petroleum and fishing sectors (CCA & CMS 2001; Wilkinson & Japp 2005a, b). Drilling activities can result in a temporary loss-of-access to fishing grounds and environmental impact assessments recommend liaison between the petroleum industry and the relevant stakeholders, specifically with the fishing sector, regarding the location of prospect wells in relation to fishing grounds and trawl lanes in particular (CCA & CMS 2001). Wilkinson & Japp (2005a) examined

the socio-economic impact of the South Coast Gas Development Project on the trawling industry. Umbilicals and pipelines are vulnerable to damage by trawl equipment (Gründlingh *et al*. 2006) and measures, including trawl exclusion zones, are required to protect this equipment. Trawl nets could be entangled by such obstructions and the vessel and crew can be placed at risk (CCA & CMS 2001). The fishing industry has expressed concern about the impact that abandoned and suspended well heads, and lost equipment (such as anchors), could have on fishing activities (Wilkinson & Japp 2005b).

Fishing can also impact on petroleum activities. Unattended fishing gear can have serious impacts on seismic surveys in particular (CCA & CMS 2001; Gründlingh *et al* 2006). Wilkinson & Japp (2005b) surveyed the types of trawl doors and ground gear used on the south coast as a component of efforts to understand and reduce offshore user conflicts in this area. The potential collision between a drilling unit and a ship or fishing vessel is considered a serious risk. SAMSA has instituted a formal traffic separation scheme on the South African south coast. A 35 km safety zone has been declared around the Oribi/Oryx production facility in addition to the 500 m exclusion zone imposed by the International Maritime Organization. A collision between a large vessel, particularly an oil-laden tanker, and a drilling rig, is likely to result in a highly significant impact on the environment (CCA & CMS 2001).

Petroleum activities also have implications for marine diamond mining through the imposition of exclusion zones around seismic survey vessels and drilling platforms, although in the case of seismic surveys, these are mostly of short duration (3–5 weeks) (Roos 2005). There have also been conflicts of interest where mining and seismic surveys were planned concurrently in overlapping areas (CCA & CMS 2001).

CHAPTER 2

Mineral prospecting and mining

Offshore diamond mining

Overview

During the Cretaceous Period (144 to 65 million years ago) marine diamonds, originating from inland kimberlite pipes, were transported seawards by rivers and deposited on gravel beaches along the southern African west coast, which are now located offshore, at depths of 150 m or more (Penney & Pulfrich 2004). Mining of marine diamond-gravels was initiated on the Namibian south coast in 1961 by Marine Diamond Company (Pty) Ltd and proved to be surprisingly successful (Clark *et al.* 1999; Penney & Pulfrich 2004). Shortly thereafter, in 1962, South Africa commenced marine diamond mining in the offshore Namaqualand concession zone, between the Orange and Olifants Rivers (Penney & Pulfrich 2004). In the early 1970s however, an international diamond market slump resulted in reduced offshore diamond mining activity, especially by smaller companies (Clark *et al.* 1999). A depletion of the lucrative inshore diamond resources during the early 1990s and the availability of improved mining technology, once again resulted in an increase in mining efforts in the offshore areas (Clark *et al.* 1999).

Diamonds in the southern African coastal region are concentrated on or near the bedrock with younger, unconsolidated sediments deposited above the older bedrock (Clark *et al.* 1999; Maree *et al.* 2002). Marine diamond mining involves the removal of unconsolidated sediments (overburden) from the sea floor using large, purpose-designed vessels operated on an anchor spread area of approximately 1 km^2 at a time—three or four anchors are spread on the seabed to enable the vessels to position themselves precisely over the area to be mined (Penney & Pulfrich 2004; Gründlingh *et al.* 2006). Overburden sediments, containing diamond-bearing gravel, are pumped or airlifted to the surface for on-board processing using one of two methods (Roos 2005). The two categories of deep-water marine diamond mining (120–150 m) currently employed are (Figure 2.1): 1, horizontal (crawler) mining where a seabed crawler fitted with a suction head is attached to a tethered hose. This system is designed to operate in overburden deeper than 4 m; 2, vertical (drill) mining where a vertically mounted drill bit (5.2–5.6 m diameter Wirth drill systems) is attached by a drill string. This system is designed to operate in overburden shallower than 4 m.

Both systems are designed to disturb the overburden allowing it to be pumped to the vessel for processing. Oversized boulders and fine tailings are immediately discarded overboard, with almost 90 % of the material pumped to the surface being returned directly to the sea (Roos 2005). The remaining gravel fraction is separated using a ferrosilicon dense medium separation system, the diamonds extracted

FIGURE 2.1.—Illustrations of the horizontal (crawler) and vertical (drill) mining technology (Roos 2005).

from the heavy fraction using an X-ray sorter, and the remaining gravel discarded in the sea (Penney & Pulfrich 2004). In Namibia, hopper-dredge mining is currently being employed offshore, which is a new technique allowing processing of 100 000 m^3 of sediment per day (compared with 10 000 m^3/day by drill mining). This mining technique enables the feasibility of the mining of low diamond density areas (Andrea Pulfrich pers. comm.).

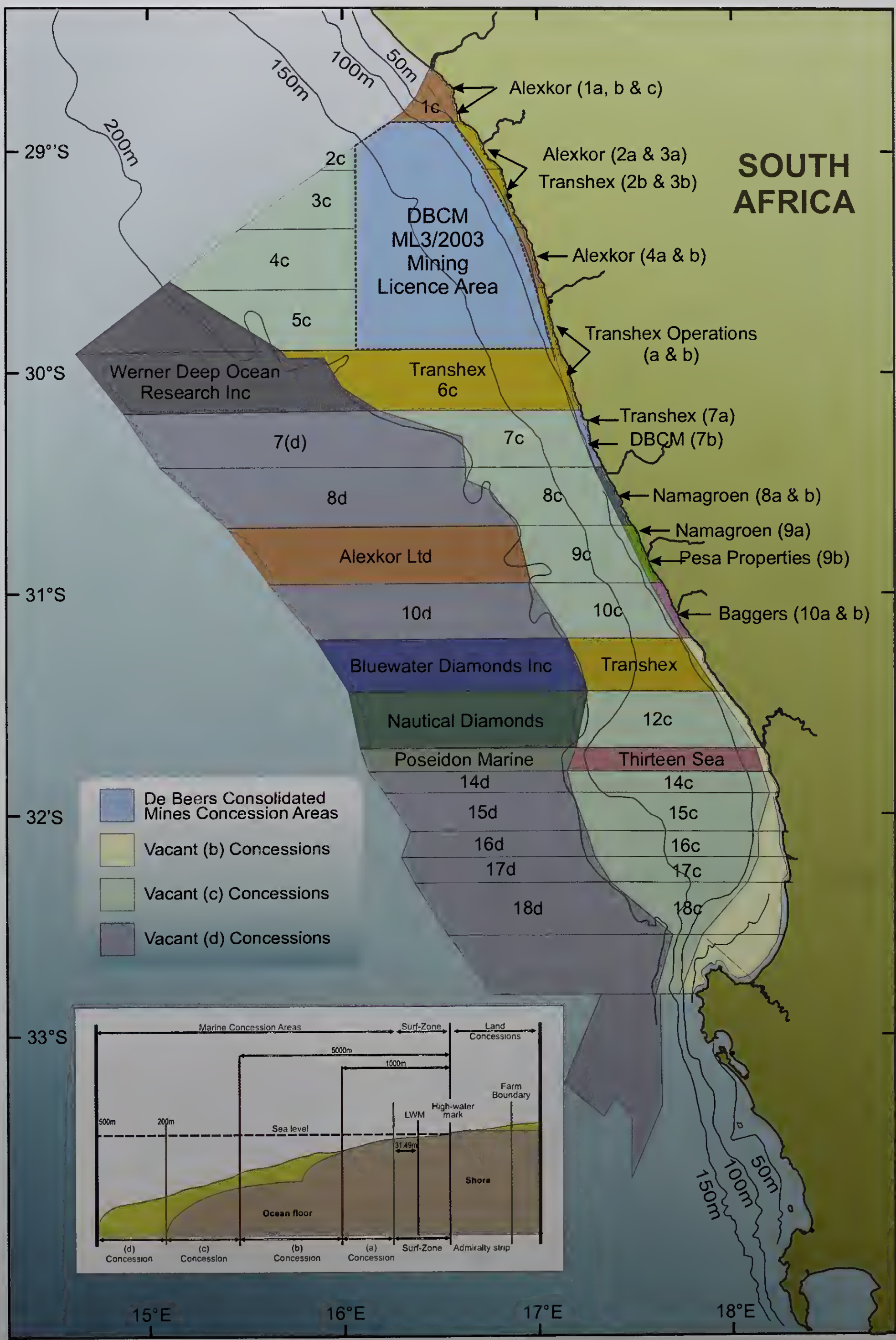

FIGURE 2.2.—Map of the South African marine diamond mining concession areas, showing the position of the ML3/2003 mining license area (L. Roos pers. comm., De Beers 2007).

The use of large dredgers, which can dredge sediments from depths of 130 m, are currently being investigated for use in future deep-water diamond mining operations. However, the feasibility and expense of pumping dredged material ashore via a pipeline is of concern (Gründlingh *et al.* 2006).

In 1994, the South African Department of Minerals and Energy (DME) established a grid network of marine mineral concession zones on the west coast of South Africa (from the Orange River mouth to just south of Saldanha Bay, Figure 2.2) extending from the high-water mark seawards to 500 m depth. Each concession area is further split into four subareas (Concessions A to D) in an offshore direction. The A Concessions are considered coastal and extend 1 km from the shoreline to ± 30 m offshore (Clark *et al.* 1999; Roos 2005). B Concessions extend from 1 km up to 5 km offshore, reaching depths of between 15 m and 100 m. C Concessions extend westwards as far as the 200 m isobath while D Concessions cover up to the 500 m isobath (Damarpupurshad 2006).

Several mining companies, such as Alexcor Ltd. and Transhex, hold **prospecting** licenses in offshore concession areas (> 30 m depth). In 2007, only De Beers Consolidated Mines (DBCM) have been granted a **mining** license for an offshore concession area, this being for the ML3/2003 license area (Figure 2.2). Whereas diamond prospecting has taken place in offshore areas for several years, full-scale mining has only just commenced (May 2007). De Beers Consolidated Mines issued a notification of commencement of mining operations in ML3/2003 with intent to initiate mining on 1 May 2007, inshore of the 150 m isobath in this concession area.

The offshore diamond mining industry is largely dominated by three companies: De Beers Consolidated Mines Ltd (primarily mid to deep concessions), Alexcor Ltd (mainly shallow concessions) and Trans Hex Operations (Pty) Ltd (shallow and deep concessions, Damarpupurshad 2006). De Beers Consolidated Mines hold a mining license for the ML3/2003 license area (the inshore portion of concessions 2c, 3c, 4c and 5c) and prospecting permits for concession areas 7c, 9c, 10c and 12c, thus being considered the largest marine mining company in South Africa. (Figure 2.2, Penney & Pulfrich 2004).

Value

South Africa's total (terrestrial and marine) diamond mining industry is ranked third most important in the world (trailing behind Botswana and Russia) and is valued at an estimate of U$1 700 million in 2005, contributing nearly 14 % of the world's diamonds (Damarpupurshad 2006). In 1997, alluvial and marine diamonds comprised approximately 10 % of South Africa's total diamond production (L. Roos, De Beers pers. comm.; Clark *et al.* 1999) with marine diamonds specifically comprising 0.35 % (nearly U$ 6 million, L. Roos, De Beers pers. comm.). Marine diamond mining contributes 0.0026 % to South Africa's annual GDP (L. Roos, De Beers pers. comm.; Damarpupurshad 2006).

Governance framework

The **Department of Minerals and Energy** is the over-riding responsible authority for diamond mining as defined under the Mineral and Petroleum Resources Development Act No. 28 of 2002 and the Mine Health and Safety Act No. 29 of 1996. Legislation requires a comprehensive Environmental Management Programme Report (EMPR) to be compiled and submitted in support of any application for a prospecting or mining right. For an EMPR to be effective, however, an Environmental Management System (EMS), compliant with the ISO 14001 code of practice, should be implemented (Penney & Pulfrich 2004). Furthermore, legislation also requires financial provision in the proposed budget for remediation of any environmental damage resulting from mining activities (Roos 2005).

Other government departments responsible for application of relevant Acts and regulations to control pollution, access to the coastal zone and damage to natural resources are:

- the **Department of Transport** for the Maritime Zones Act No. 15 of 1994; Sea Shore Act No. 21 of 1935; Merchant Shipping Act No. 57 of 1951; Marine Pollution Prevention by Ships Act No. 2 of 1986; Marine Pollution Control and Civil Liability Act No. 6 of 1981; Wreck and Salvage Act No. 94 of 1996; Marine Traffic Act No. 2 of 1981; and National Road Traffic Act No. 93 of 1996;

- the **Department of Environmental Affairs and Tourism** for the National Environmental Management Act No. 107 of 1998; Environmental Conservation Act No. 73 of 1989; National Environmental Management: Biodiversity Act No. 10 of 2004; and

Atmospheric Pollution Prevention Act No. 45 of 1965; with their Marine and Coastal Management branch being responsible for the Marine Living Resources Act No. 18 of 1998; and Dumping at Sea Act No. 73 of 1980;

- the **Department of Arts and Culture** for the National Heritage Resources Act No. 25 of 1999;
- the **Department of Water Affairs and Forestry** for the National Water Act No. 36 of 1998.

The Marine Diamond Mines Association (MDMA) represents the interests of mining companies that operate in coastal and marine environments. This Association was formed in response to the government notice of intention to declare the proposed Namaqualand Marine Protected Area in 2004.

Biodiversity impacts

Globally, mining of diamonds in the marine environment only takes place on the west coast of southern Africa. The impacts of marine diamond mining were first investigated in 1991 when De Beers Marine commissioned a group of specialists to undertake an Environmental Impact Assessment (EIA) of the potential effects of deep-sea diamond mining activities in this area. This study resulted in several specialist reports providing the first known environmental studies for deep-sea diamond mining operations in southern Africa (Roos 2005). The overall conclusion of the EIA was that environmental impacts are not of sufficient significance to preclude continuation of mining (Roos 2005), although several impacts, pertinent to overall marine biodiversity, were identified.

Disturbance of seabed sediments and benthic communities is considered the principal impact of marine mining, resulting in the top ~20 cm of sediment and the associated benthic fauna being unavoidably destroyed by mining activities. The composition and structure of benthic macrofauna are closely associated with sediment composition (Field & Parkins 1997; Parkins & Field 1998; Pulfrich & Penney 1999; Steffani & Pulfrich 2004). Disturbance of the sediment results in a significantly modified benthic macrofauna community, which can take up to five years to recolonize (Van der Merwe 1996; Pulfrich & Penney 1999; Steffani & Pulfrich 2004). Sediment disturbance, such as that imposed by mining activities, may cause species selection for physical robustness and tolerance to air exposure more than resistance to the actual disturbance (Savage *et al.* 2001). Organic pollution (enriched sediment and potential chemical contaminants in the sediment) can exclude more chemically sensitive macrofauna species (Savage *et al.* 2001). Overall, sediment disturbance, such as that imposed by mining activities, is known to result in a decreased abundance and biomass of large, long-lived, slow-growing macrofauna species, whereas small, fast-growing pioneer species increase in abundance and tend to dominate the community composition (Olsgard & Gray 1995; Newell *et al.* 1998; Hall 2001; Kaiser *et al.* 2002). This shift in community composition is usually associated with a decrease in overall diversity, and can have negative impacts on the overall ecosystem functioning (Hall 2001; Kaiser *et al.* 2002).

Discharged gravel and fine sediment (tailings) are deposited on the sea floor during the mining process (Figure 2.3) and can alter the sediment composition and/or smother benthic fauna in a localized area (Griffiths *et al.* 2004). This impact is largely considered to be minor due to the comparatively small area in which such deposits are believed to settle. Fine sediment plumes extend for a few kms from the mining vessel but the rapid and substantial dilution that occurs through the naturally dynamic nature of the environment, results in a small total area of impact (Penny & Pulfrich 2004). There has been concern over the re-suspension of heavy metals through mining activities (Attwood *et al.* 2000). Heavy metal concentrations in the tailings have been evaluated and are considered to be well below the guideline levels and are thus not considered likely to contribute to toxicity of the environment (Penny & Pulfrich 2004). The risk of pollution from disposal of tailings has been ranked as 'low' in the Specialist Scoping report for mining operations in the ML3 license area (Penny 2005). Furthermore, the impact on phytoplankton communities (reduction of light), nutrient enrichment, remobilization of contaminants and oxygen consumption (decomposition of organic matter) as a result of sediment plumes, have been found to be limited and localized, and not considered to have extensive environmental impacts (Penny & Pulfrich 2004). A change in fish communities, as a result of sediment plumes, has also been investigated. However, results indicated that any potential change would be short-lived and some fish species may even temporarily favour the plumes, as they provide shelter from visual predators (Clark *et al.* 1999).

Acoustic vibrations and noise, caused by seismic survey activities prior to prospecting or mining, were considered to have low impact significance on the marine environment, particularly marine mammals, in the Environmental Impact Assessment for De Beers Mining license area ML3 (Roos 2005). Low-frequency air guns are no longer used for seismic surveys and the survey equipment currently in use emits low-source noise levels. The improved technology and understanding of seismic impacts has shown that seismic activity in marine mining is of low significance (Roos 2005). A mitigation measure to ensure that the impact of seismic activity is low on the marine environment is to implement 'soft starts' whereby the noise level of the equipment used is initiated at very low levels and is gradually (over at least twenty minutes) increased to full operational strength. This is believed to allow any marine mammals within the vicinity of seismic operations to move out of the area and prevent being negatively affected (Roos 2005).

The only actively mined offshore area in South Africa's EEZ is that of the ML3/2003 license area, De Beers Consolidated Mines, wherein only 0.5 % of the area has potentially viable diamond reserves, and only 0.07 % are considered economically viable for mining (Penney & Pulfrich 2004). This implies that it is highly unlikely that more than 1 % of a mining concession area will ever be mined, and the overall impact from discharged sediment is considered minimal (Roos 2005). There is however, concern that should diamond concentrations occur in a particular unique habitat, the biodiversity of that habitat would largely be lost with the impacts incurred by mining activities (Attwood *et al.* 2000).

Issues of conflict

The fishing industry has, in the past, expressed concerns about the impacts of marine mining on the west Coast rock lobster (*Jasus lalandii*) resource and on demersal trawl fisheries (Penney & Pulfrich 2004). Concerns of the rock lobster fishery relate primarily to activities of the boat-based and shore-based diver operations in the shallower A and B Concessions. Deep-water mining operations in the C Concessions (the only one currently being mined is ML3/2003) do not overlap or interact with the rock lobster fishery, which occurs in depths < 25 m (Roos 2005). The demersal trawl fishery on the west coast of South Africa, largely targets fish species that occur in association with smooth, organic-rich sand and muddy sand sediment plains (Birch & Rogers 1973). These sediments occur largely on the outer continental shelf at depths > 200 m, in the deeper D Concession mining areas, which have not as yet (2007) been exploited due to mining technology limitations (Penney & Pulfrich 2004). As yet, there is no direct area overlap between offshore marine mining and demersal trawl fishing. Marine resources contributing to commercial fisheries are not considered to be impacted by seismic survey activity (Roos 2005).

The area of overlap between offshore mining and petroleum (oil and gas) activities on the west coast of South Africa occurs between the 200 m and 600 m isobaths (Penney & Pulfrich 2004; Wilkinson & Japp 2005a). The D Concession are the only potential mining areas where offshore mining and petroleum activities might interact. As yet, only prospect-

FIGURE 2.3.—Coarse sediment discharge plume during mining operations (Penny 2005).

ing licenses have been issued in D Concessions. There is potential for future user-conflict between these two sectors (CCA & CMS 2001).

Other offshore mining

Potassium and glauconite

Extensive potassium and phosphorous-rich deposits occur on the continental shelf of the southern and west coasts of South Africa and Namibia (Coles et *al*. 2002). The largest known concentration of glauconite in southern Africa occurs west of Saldanha Bay in depths between 200 m and 300 m (Coles et *al*. 2002). Isolated occurrences of authogenic phosphate pellets and extensive diagenic phosphate rocks occur along the continental shelf-break (200–300 m isobath) off the west coast and Agulhas Bank of South Africa (Coles et *al*. 2002). Some investigation into the feasibility of mining these deposits for phosphatic and glauconite components (used to supplement the fertilizer industry) have been conducted (Rogers & Bremner 1991). Thus far, these studies have concluded that due to the expensive nature of marine offshore mining and the availability of these components from terrestrial sources in other countries, it is not economically viable to initiate prospecting or mining ventures for these resources (Coles et *al*. 2002). Furthermore, it is acknowledged that considerable user-conflict is likely to exist with the fishing industry, should the deposits of glauconite and phosphate be mined in South Africa.

Heavy metals

Richards Bay Minerals (RBM) were issued a five-year heavy metals prospecting permit by the Department of Minerals and Energy in 2004 for an area on the northern KwaZulu-Natal coast, stretching between Richards Bay in the south and Cape St Lucia in the north (Jenvey 2005). In 2005, the company was in its third phase of exploratory surveys to determine the viability of offshore mining for ilmenite (converted to titania slag and iron), rutile and zircon on the continental shelf of its Tisand and Zulti North leases (Business Day 14th July 2005). If RBM determines that mining for these heavy minerals is feasible and economically viable and a mining permit is granted, they will implement a dredge-type system, similar to that used by offshore diamond mining activities. Limited information is currently available as to the current findings or intentions of the company.

Manganese

Manganese nodules, enriched in valuable metals such as nickel, copper and cobalt, occur in waters exceeding 3 000 m off the west and south coasts of South Africa (Rogers & Bremner 1991). Exploratory surveys report that the nickel, copper and cobalt contents of most of these manganese nodules fall below the 2 % economic cut-off grade (Rogers & Bremner 1991). Surveys in the area north of 33° S in the Cape Basin and off northern Namaqualand show evidence of mineral grade nodules. However, no prospecting licenses have yet been applied for in this respect (CCA & CMS 2001: vol. 2.).

CHAPTER 3

Commercial fishing

Introduction

Commercial fisheries and recreational anglers in South Africa are reported to catch over 250 marine species, although fewer than 5 % of these are actively targeted by fisheries, yet comprise 90 % of the landed catch (Mann 2000). There are approximately 15 major fishery sectors (Table 1) that operate in South Africa's offshore region (deeper than 30 m), contributing 0.5 % to the national GDP (Sauer *et al.* 2003). The pelagic purse seine fishery supplies the greatest tonnage of fish landed per annum with the demersal trawl fishery landing the second largest catch (Fishing Industry Handbook 2004). The demersal trawl sector represents the highest value fishery in South Africa (Figure 3.1.). The fishing industry (primary, secondary and tertiary aspects) provide employment for nearly 28 000 people in South Africa (Sauer *et al.* 2003) constituting an extremely important contribution to South Africa's social and economic wellbeing. Profiles of the 15 major fishing sectors are provided in this section of the report, including a brief history of each fishery, potential impacts on biodiversity and possible conflict issues with other offshore users.

Governance framework

Commercial and recreational fishing in South Africa is principally governed by the Marine Living Resources Act No.18 of 1998, although various other legislation and policies are in place to facilitate, supplement and support the implementation thereof. Each commercial fishery sector has developed management policy documents, updated annually, that are used to provide stringent guidelines in implementing management measures for the sustainable use of marine resources. The Department of Environmental Affairs and Tourism (DEAT), Directorate: Marine and Coastal Management (MCM) are the designated implementing agents for national management of the fishing industry.

TABLE 1.—Size, participants and value for all fishing sectors (www.feike.co.za, May 2007)

	Vessels	Rights holders	Jobs sustained	Duration of rights	Gross asset value
Hake deep-sea trawl	45	46	8 900	2006–2020	R2.4 billion
Hake inshore trawl	31	17	1 480	2006–2015	R1.5 billion
Hake longline	64	132	1 495	2006–2020	R182 million
Hake handline	39	39	342	2006–2013	
Midwater trawl	6	15	527	2006–2015	R2.4 billion*
Traditional line fish	450		3450		
Tuna pole	157	152	2 516	2006–2013	R125 750 990.00
Large pelagics	31	43		2005–2015	
Small pelagics	101	95	15 133	2006–2020	R1.2 billion
Squid	138	121	2 400	2006–2013	R441 million
Crustacean trawl					
West coast rock lobster (offshore)	105	195	1 058	2006–2015	R941 million
South coast rock lobster (trap)	9	12	441	2005–2020	R127 million
Natal deep-water rock lobster					
Exploratory fishing					

* Gross asset value for midwater trawl not reported separately from hake deep-sea trawl due to close links between these fisheries (shared vessels, gear, among others).

The Marine Living Resources Act No. 747 of 1998 (MLRA) and the supplementary regulations published, govern all extractive exploitation of living marine resources in South Africa (i.e. fishing) through scientifically based and publicly acceptable operational management procedures. This Act repeals most of the old Sea Fishery Act No. 12 of 1988 and its preamble reads as follows: 'To provide for the conservation of the marine ecosystem, the long-term sustainable utilization of marine living resources and the orderly access to exploitation, utilization and protection of certain marine living resources; and for these purposes to provide for the exercise of control over marine living resources in a fair and equitable manner to the benefit of all the citizens of South Africa; and to provide for matters connected herewith'.

It affords protection to every species of sea animal (vertebrate and invertebrate), including the spawn or larvae of such sea animal, but excluding any seal or sea bird. Fish and marine organisms are protected by means of prohibition against their catching, disturbance or possession, although the Act makes provision for the granting of commercial, recreational and subsistence fishing rights. The Act emphasizes fair and equitable access to resources, the gradual transformation of fishing methods, the development of fees for utilization and a favourable business environment in fisheries. The Act provides for a principle of national control and co-ordination and places responsibility for resource allocation decisions with the Minister of Environmental Affairs and Tourism. The primary function of the national government directorate MCM, is to provide scientific liaison, logistic, administrative and personnel management support to the Minister of DEAT, to meet various international commitments and to fulfill national, provincial and parastatal responsibilities. MCM aims to facilitate sustainable development of marine and coastal resources by integrating human needs and natural resources.

The National Environmental Management Act No. 107 of 1998 (NEMA) is South Africa's overarching environmental legislation. The Act emphasizes the principle of co-operative governance and ensures that the environmental rights provided for in the Constitution are protected and fulfilled. Although the Act requires the lead agent (DEAT) to ensure effective custodianship of the environment, it also acknowledges that the State alone is unlikely to be able to manage the environment effectively. The scope for public involvement in environmental management is provided for in the Act, which includes the ability to institute private prosecutions and gives the public the ability to participate in the management of the environment. The Act also makes provision for the issuing of regulations in order to carry out the purposes and provisions of NEMA.

Several fishing sectors in South Africa have formed associations in order to promote and protect the interests of its members. The various associations are non-profit organizations fulfilling, *inter alia*, the following functions:

- represent members in negotiations with the government, legislative or administrative bodies;
- consider, report, advise and make representations on existing or contemplated legislation affecting the industry;
- collect and disseminate information likely to be of use to members;
- co-operate with organizations which may be established to deal with matters that affect the members;
- assist members with administrative and technical matters regarding the industry.

Some of the larger associations of relevance to offshore marine fisheries include:

Association of Small Hake Industries

South African Pelagic Fishing Industry Association

South African West Coast Rock Lobster Association

South Africa Deep Sea Trawling Industry Association (SADSTIA)

South African Marine Linefish Management Association

South African Midwater Trawling Association

South African Squid Management Industrial Association

South African Tuna Association

Shark Longline Association

South Coast Rock Lobster Association

The National SMME Fishing Forum

Hake deep-sea trawl

Overview

The demersal trawl fishery started in the early 1900s off southern Africa, targeting the two Cape hake species, *Merluccius capensis* and *M. paradoxus*. Initially the fishery was concentrated close to the port of Cape Town where

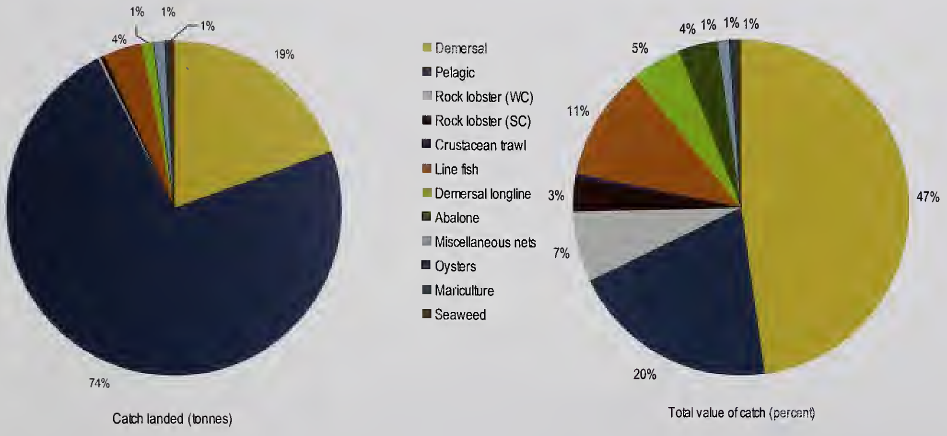

FIGURE 3.1.—Landings and value of commercial fishery sectors in South Africa in 2000. (source: Fishing Industry Handbook 2004).

total annual landings of shallow-water hake (*Merluccius capensis*) were approximately 1 000 tons just after World War I (Lees 1969; Payne 1989). By 1950, after World War II, annual landings had increased to 50 000 tons and fishing centred around Saldanha Bay, reflecting improved technology and an expansion of the fishing grounds (Payne & Punt 1995; Griffiths *et al.* 2004). In the early 1960s, international fleets (Russian, Japanese and Spanish trawlers) escalated the total landings of hake to 160 000 tons (Payne 1989; Payne & Punt 1995). These high catch rates led to substantial overexploitation of the demersal hake resource in South Africa and Namibia (Payne 1989). The International Commission for the Southeast Atlantic Fisheries (ICSEAF) was established in 1972 to manage the hake resource (Griffiths *et al.* 2004). In 1975, ICSEAF introduced a minimum mesh size of 110 mm, a system of international inspection (observer programme) and allocated quotas to each member country participating in the hake fishery (Payne 1989). In 1977, South Africa declared a 200-nautical mile economic exclusion zone (EEZ) subsequently excluding the majority of foreign fishing effort and thereby reducing the hake catches off South Africa (Payne 1989; Payne & Punt 1995; Griffiths *et al.* 2004). South Africa began rebuilding its hake resource by introducing conservative annual total allowable catch (TAC) quotas in 1978 (Payne & Punt 1995). The fishery was also formally separated into offshore and inshore sectors, targeting different hake species; deep-water hake (*Merluccius paradoxus*) and shallow-water hake (*M. capensis*) respectively, divided at the 110 m depth contour. Since 1999, the hake resource has started showing early warning signs of depletion and as a precautionary measure, the TAC has been reduced by between 2 000 and 4 000 tons in recent years. The status of the stocks and the associated environmental parameters are being carefully monitored and managed with caution.

The deep-sea hake fishery primarily targets deep-water hake (*M. paradoxus*) which occurs in waters between 200 m and 800 m off the South African west coast continental shelf. On the south coast (defined as eastwards of 20°E longitude) deep-sea trawlers are not permitted to fish shallower than 110 m or within 20 nautical miles of the coast, concentrating fishing effort on the offshore edge of the Agulhas Bank (Figure 3.2). Offshore fishing grounds extend in an unbroken band southwards from approximately 300 m depth off Hondeklipbaai on the west coast (30°S) to the southern tip of the Agulhas Bank (Figure 3.2). Little offshore trawling occurs between the southern edge of the Agulhas Bank and offshore of Plettenberg Bay, due to rocky terrain (Wilkinson & Japp 2005c). The heavily trawled offshore area between Plettenberg Bay and Port Elizabeth consists of sand or muddy sediments, a habitat type known to yield good trawl catches (Wilkinson & Japp 2005c). Walmsley *et al.* (2007) recognize the following potential management units for the offshore demersal trawl sector: West coast shallow (< 300 m); West coast shelf edge (301–500 m); and West coast deep (> 500 m).

Vessels partaking in the trawl fishery are mostly modern stern trawlers ranging in length from 23 to 90 m (Wilkinson & Japp 2005c). A detailed description of trawl gear used in South Africa is provided by Wilkinson & Japp

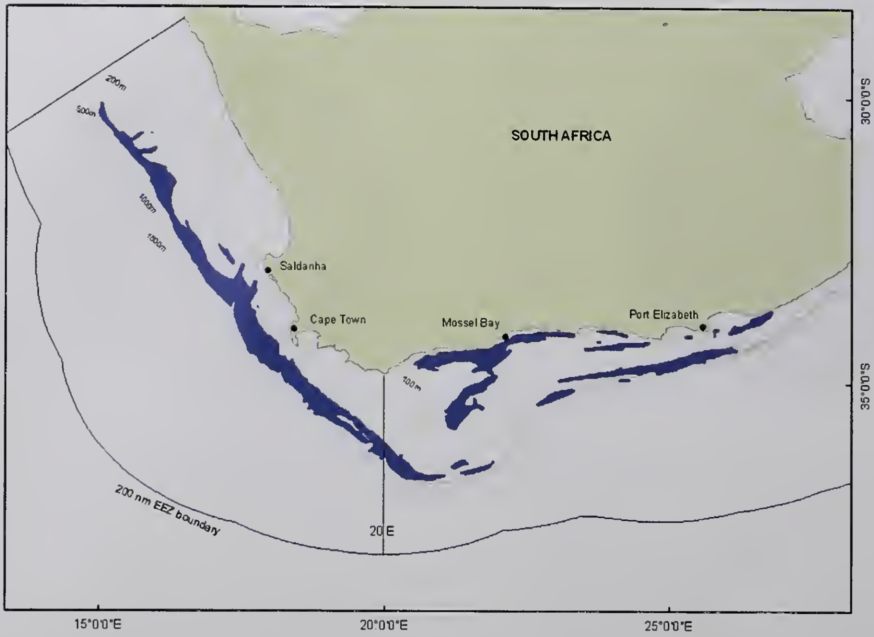

FIGURE 3.2.—Total trawl (inshore and offshore) effort distribution around the South African coast (from: Wilkinson & Japp 2005c).

(2005c). In summary, the typical trawl configuration used in South Africa is that of 'otter trawls' which make use of two trawl doors (otter boards) dragged along the sea floor ahead of the net to hold the mouth of the net open (Figure 3.3). The net is comprised of a footrope, that may include chains, bobbins or weights, the large-mesh 'belly' and 'wings' of the net and the finer mesh cod-end (restricted to 110 mm), which retains the catch. The main warps and bridal wires attach the trawl doors to the warp drum on board the ship and are used to tow the net through the water. The trawl doors vary in size and shape and, being the heaviest component of the gear (up to 3 500 kg each), frequently come in direct contact with the sea floor (Wilkinson & Japp 2005c). The area of the trawl gear in contact with the sea floor is dependant on the shape and size of the doors, the speed of towing and the power of the vessel. Rockhopper gear is also frequently used to allow the net to 'hop' over rocky ground and other obstructions. Rockhopper gear consists of rubber discs ranging in diameter from 250 mm to 610 mm, spaced along the footrope at regular intervals. Use of this type of gear allows trawling to take place in areas previously protected by their rockier nature. Trawl nets are deployed from the stern as the vessel steams ahead and are generally towed for between one and four hours, typically catching about 5 tons of fish (Wilkinson & Japp 2005c). The entire catch is hauled up from depths ranging between 200 m and 600 m, landed on the deck and sorted into target and bycatch species and size categories. The component of the catch without commercial value is discarded overboard.

Biodiversity impacts

A risk assessment identified the impact of trawling on the benthic habitat and biota as a major threat to the sustainability of the South African demersal hake fishery (Nel 2005). Shannon *et al*. (2006) stated that trawling on benthic habitat and biota was of major concern to the ecosystem and should be addressed as part of South Africa's Ecosystem Approach to Fishing commitment (World Summit on Sustainable Development, WSSD 2002, recommendation 29d and 31c). The direct and indirect impacts of the South African demersal trawl fishery remain poorly understood and local studies are necessary to assist in quantifying these impacts. The specific ecological effects of the demersal hake fishery are difficult to estimate. However, three main impact aspects should be considered, namely, substratum damage, bycatch and discards. Demersal towed fishing gear, such as that employed in the demersal hake fishery, are known to damage benthic habitats and the associated biota, due simply to the nature of the fishing activity, which involves dragging a net over the sea floor. The extent of impact is influenced by the size of the fished area, frequency

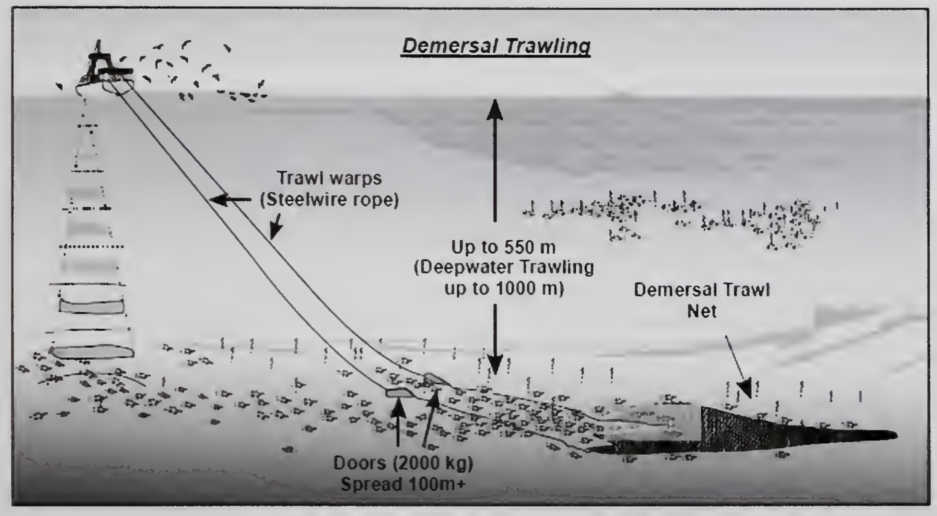

FIGURE 3.3.—Schematic representation of typical otter trawl configuration employed by the majority of the demersal hake trawl fishery (source: Gründlingh et al. 2006, Large Marine Ecoystems 14, figure by T. van Dalsen).

of fishing effort and the habitat type (Kaiser et *al*. 2003). Structurally complex habitats (coral reefs and seagrass beds) and habitats that are relatively undisturbed by natural perturbations (e.g. deep-sea benthic environments) are considered to be highly susceptible to impacts from trawl gear (Jennings & Kaiser 1998; Watling & Norse 1998; Kaiser *et al*. 2002; Queiros *et al*. 2006).

The disturbance caused by fishing activities was previously speculated to enhance biotic production and generate food for target species. However, global studies have shown that the removal of high biomass species, such as fish, generally reduces overall ecosystem biomass and species diversity, ultimately lowering productivity (Jennings & Kaiser 1998; Kaiser *et al*. 2002). Fishing pressure has been found to lead to a decline of larger, slow-growing, late-maturing species and an increase in abundance of smaller, faster-growing, early-maturing species (Jennings *et al*. 1999). Scavengers and small-bodied, fast-growing organisms (e.g. polychaetes) tend to rapidly recolonize and proliferate in heavily fished areas, reducing species diversity (Ball *et al*. 2000). Areas frequently trawled over a long period of time tend to support a benthic community rich in predatory and scavenging organisms (Kaiser & Spencer 1996; Sparks-McConkey & Watling 2001). These organisms, being highly mobile, are able to rapidly colonize recently trawled areas to feed off the infauna that would have been unearthed and re-suspended by passing trawl gear (Wilkinson & Japp 2005c). Changes in the benthic community composition, as a result of fishing activities, are likely to lead to changes in the community composition of resident fish species (Bianchi *et al*. 2000; Kaiser *et al*. 2002). Furthermore, demersal fishing over soft-bottom substrates results in large-scale re-suspension of sediment which can result in changes in the nutrient fluxes between the sediment and water interface (Churchill 1998). Organic matter in the sediment is re-suspended in the disturbance event and rapidly taken up by opportunistic species, which then flourish (Churchill 1998). Demersal fishing undeniably results in a more homogeneous environment, devoid of structural complexity, supporting a lower diversity and biomass of a large proportion of marine species, including those of commercial importance (Collie *et al*. 1997). The broader impact of these modifications to the ecosystem has yet to be clearly defined within the South African context and further studies are underway.

The indiscriminate nature of the trawl fishery results in a proportion of the catch being made up of bycatch species, some of which have a good market value and are retained on board (Japp 2004). Valuable bycatch species of the offshore demersal trawl fishery include monk (*Lophius vomerinus*), kingklip (*Genypterus capensis*), angelfish (*Brama brama*), snoek (*Thyrsites atun*) and horse mackerel (*Trachurus trachurus capensis*). In waters deeper than 500 m on the west coast, the bycatch includes other species such as oreos and slimeheads (*Hoplostethus* spp.) some of which are commercially valuable (Dave Japp pers. comm.). The market value of kingklip and monk are sometimes higher than the target hake species and fishing activities are known to be directed towards these bycatch species,

TABLE 2.—Summary of bycatch and other concerns in demersal trawl sectors as identified by Walmsley *et al.* (2006, 2007)

Sector	**Bycatch concerns**	**Discard & other concerns**
Offshore hake-directed (east coast)	Bycatch = 15 % of value of landed catch	Discard of hake, jacopever; targeting of kingklip
Offshore hake-directed (west coast)	Bycatch = 30 % of value of landed catch; much of bycatch not utilized	Targeting of large *Merluccius capensis* (due to high export value) of concern; discard of small hake of some concern
Inshore hake-directed fishery	Bycatch = 36 % of value of landed catch; bycatch of line fish and chondrichthyans of concern; targeting of panga should be monitored	Discard of hake of some concern
Inshore sole-directed fishery	Capture of overexploited line fish of concern; bycatch of juvenile silver kob and other line fish of serious concern; chondrichthyans contribute more than 10 % of catch	Serious concern about discarding of juvenile hake (20 % of hake caught discarded)

a practice that has occurred with increasing frequency in recent years. Kingklip and monk stocks are believed to be small, vulnerable to over-fishing and are not considered sustainable for full-scale commercial exploitation (Japp 2004). The kingklip stock in particular is recovering from severe overexploitation in the 1980s and is not considered viable to support a targeted fishery (Japp 2004). Walmsley *et al.* (2007) show the efficacy of monk-directed trawling where net modification for targeting this species raised the proportion of monk from 3 % to 33 % of the catch by mass. Bycatch concerns in this fishery are reportedly being addressed through a bycatch management plan (Japp 2004). Key concerns for each proposed demersal trawl management unit, as identified by Walmsley *et al.* (2007), are shown in Table 2. Bycatch in water deeper than 500 m is less than that on the shelf: 9.6 % of the total catch compared to 34.6 % in the 0–300 m depth range (Walmsley *et al.* 2007).

Bycatch species retained in the demersal trawl net that are not of any significant commercial value (such as grenadiers) or are too small for market demands (specifically hake), are dumped overboard (Walmsley *et al.* 2006). The discarding of small hake in favour of larger, more valuable fish (highgrading) is of particular concern to the sustainability of the fishery (Walmsley *et al.* 2006). The ecological impacts of dumping large quantities of dead fish on the environment and the health of the ecosystem have not been conclusively established.

Issues of conflict

The hake demersal trawl fishery, being the largest and most valuable fishery in South Africa, frequently experiences conflict with several other fishery sectors. With the reintroduction of the hake longline fishery in 1994, considerable conflict between the hake demersal trawl and longline sectors has developed (see hake longline fishery). Frequent interactions between trawlers and longliners are reported, with substantial complaints of obstruction to fishing activities and damage to gear as a result of fishing area and target species overlap (Fairweather 2002). Longliners are known to target larger, adult hake, impacting on spawning females (Japp 2004). Trawlers are being forced to fish in deeper waters due to declining catch rates, with the aim of landing larger fish, having higher market demand (high-grading, CCA & CMS 2001: vol. 2). The conflict in target fishing areas between these sectors is increasing, with longliners reportedly fishing with increasing frequency in soft bottom areas and deeper waters, such as those targeted by trawlers (CCA & CMS 2001: vol. 2). Areas of particular conflict between trawlers and longliners include the Cape Valley and the Butterball area (commercial grid blocks 469 and 505 respectively, I & J trawl skippers pers. comm.).

The occasional, yet substantial bycatch of snoek (*Thrysites atun*) in the demersal trawl fishery has resulted in issues of conflict between the trawl and line fish sectors (Japp

2004). Snoek, a target species of the line fish sector, form an important component to this fishery and removal of the resource by the trawl fishery is viewed with contempt by the line fishers.

Conflict exists between the demersal trawl fishing sector and petroleum and diamond mining operations with respect to area of activity. Currently active diamond mining activities are restricted to the De Beers ML3 concession area just south of the Orange River mouth. However, this area is not considered to directly overlap with trawl grounds. Further implications and concerns over mining activities are reported in the Offshore diamond mining section of this report.

The potential for conflict between the demersal trawl fishery and petroleum activities is considered to be highly relevant with drilling activities temporarily preventing fishing in certain areas. There is considerable concern from the trawl industry regarding the impact of well heads and lost equipment from petroleum activities on the fishery, specifically with respect to such equipment obstructing fishing activities in trawl lanes (Wilkinson & Japp 2005a). These conflicting uses of offshore marine areas are discussed further in the Petroleum Activities section of this report.

Hake and sole inshore trawl

Overview

The inshore hake trawl fishery was unofficially initiated in the 1950s by an increase in the number of small trawling vessels that were able to operate close inshore, targeting the valuable Agulhas sole (*Austroglossus pectoralis*) and shallow-water hake, *Merluccius capensis* (Sauer *et al*. 2003). It was only in 1978 that the demersal fishery was formally separated into offshore and inshore sectors, with the inshore sector receiving annual total allowable catch (TAC) quotas, independently, for hake and sole, since 1982 (Sauer *et al*. 2003; www.seis.sea.uct.ac.za, May 2007). South Africa manages the inshore hake trawl fishery as part of a 'hake collective' whereby legislation (MLRA) prescribes an annual 'global' TAC for all hakes (both shallow- and deep-water species combined) set by the Minister of Environmental Affairs and Tourism. The 'global' TAC is then subdivided among the various fishery sectors that target hake with 83 % of the TAC allocated to deep-sea trawl, 6 % to inshore trawl, 10 % shared between hake handline and longline and 1 % allocated for bycatch of the mid-water trawl fishery (www.seis.sea.uct.ac.za, May 2007).

Inshore trawl grounds are restricted southwards from Cape Agulhas in the west to the mouth of the Great Kei River in the east (Permit conditions: hake and sole inshore trawl 2007). In the Agulhas Bank area, the trawl grounds are mostly close inshore in the vicinity of Mossel Bay with a distinct offshore area on the central and eastern edge known as 'The Blues'. The Blues fishing area is exploited by both inshore and offshore fisheries (Wilkinson & Japp 2005b). Inshore trawling is most intense along the 100 m isobath with no inshore permit holders allowed to fish deeper than 110 m or to 20 nautical miles from the coast, whichever is the greatest distance (Wilkinson & Japp 2005b; Permit conditions: hake and sole inshore trawl 2007). Agulhas sole are targeted in 50–80 m of water between Mossel Bay and Struisbaai in areas where the sediment is dominated by muddy sand (www.seis.sea.uct.ac.za, May 2007). Trawling is not permitted in most of the shallow bays and inlets along the coast and the cod end mesh size must be no smaller than 75 mm, as detailed in the Permit conditions: hake and sole inshore trawl (2007).

The inshore trawl fishery operates from smaller stern or side trawlers, between 14 and 30 m in length, restricted to less than 1 000 hp engine capacity (Wilkinson & Japp 2005b). This restriction imposes an automatic limit on the gear configuration with a forced reduction in the trawl warp diameter, size of the trawl doors and nets. Further limitations on the gear include a mesh size of 75 mm stretched mesh and no rockhopper gear is permitted.

Biodiversity impacts

The general concerns for biodiversity impacts of the hake inshore trawl fishery are similar to those identified for the offshore demersal trawl fishery on the west coast of South Africa (see Hake deep-sea trawl fishery section above). These include damage to benthic habitats, high incidence of bycatch and discarding of low value or small fish (Table 2).

The inshore hake trawl fishery is known to encounter a substantial high-diversity bycatch as a result of high fish diversity occurring on the Agulhas Bank (Wilkinson & Japp 2005a; Walmsley *et al*. 2007). The majority of the bycatch is made up of horse mackerel (*Trachurus trachurus capensis*) and panga (*Pterogymnus laniarius*). However, several other line fish

species are also frequently landed, although mostly in low abundance (Wilkinson & Japp 2005a). These include, among others, carpenter (*Argyrozona argyrozona*), white stumpnose (*Rhabdosargus globiceps*) and white steenbras (*Lithognathus lithognathus*), the stocks of which are all considered overexploited or collapsed (Mann 2000; Griffiths 2000). Other reef fish frequently contributing to trawl bycatch include red roman *Chrysoblephus laticeps*, john brown *Gymnocrotaphus curvidens*, parrotfish (Scaridae family), bronze bream *Pachymetopon grande*, and bank steenbras *Chirodactylus grandis* (C. Wilke, Marine and Coastal Management, MCM pers. comm.). The legal sale of such trawl bycatch species exacerbates the problems of conflict and pressure on line fish stocks. The inshore trawl sector reports high catches of overexploited line fish such as red stumpnose, with 9.7 tons caught in 2005 (Fishing Industry Handbook 2006). A total of 703 tons of panga and 71.3 tons of white stumpnose were reported in the same year. In many instances undersize line fish proffered for sale are traced back to trawl bycatch, particularly in the case of red roman. Catches of slow-growing elasmobranchs such as the biscuit skate (*Raja straelieni*) are also of concern. As much as 251 tons of skates were reportedly caught during 2005 (Fishing Industry Handbook 2006).

The incidental capture of aggregations of juvenile silver kob (*Argyrosomas inodorus*) in the inshore trawl fishery is of particular concern (Walmsley *et al.* 2006). The area of operation of the inshore trawl fishery strongly overlaps with juvenile silver kob (*Argyrosomus inodorus*) nursery areas, resulting in a significant amount of undersized kob contributing to the trawl bycatch (C. Wilke pers. comm.).

There is concern that bobbin-gear and tickler chains, once extensively used by local and foreign trawlers, have damaged temperate reef habitat on the Agulhas Bank while targeting reef and other demersal fish, particularly Panga, *Pterogymnus laniarius*, and monkfish, *Lophius vomerinus* (Attwood *et al.* 2000). There are, however, no local baseline data to test these hypotheses. Thirteen bays on the south coast are protected from trawling (Permit conditions: hake and sole inshore trawl 2007) and comprise soft-sediment benthic communities. These bays are, however, small, close inshore or include rocky reefs, which make trawling hazardous anyway. Their effectiveness as representative bays protected from trawl impacts has not yet been assessed.

Substantial damage of unique habitats, such as lace coral (razorblades) and cold water coral communities occurring on the south coast are reported as a result of demersal inshore trawling (P. Simms pers. comm.).

Substantial quantities of the large gastropod, *Bullia* sp. (known as the *bokhoring* shell) were historically caught in the sole-directed demersal trawl fishery in the inshore regions of the south coast, such that fishers were known to be forced to cut their nets to release the large quantities of trawled gastropods. Catches of this magnitude are no longer reported and the large *Bullia* sp. seldom occurs in trawl nets (P. Simms pers. comm).

Issues of conflict

The frequent and occasionally substantial bycatch of several line fish species (especially juvenile silver kob) in the hake inshore trawl fishery results in conflict with the line fish sector (C. Wilke pers. comm.). There is also some level of conflict between the inshore trawlers and the hake handline fishery with respect to overlap in target species (hake) and the area fished.

The inshore demersal trawl fishery on the south coast encounters conflict with the hake longline fishers, similar to that experienced by offshore demersal trawlers on the west coast and offshore Agulhas region (see Hake deep-sea trawl fishery and Hake longline fishery sections). The areas of overlap between the inshore trawl and the hake longline sectors are considerably less so than for other sectors.

There is considerable overlap of target area for petroleum mining and demersal trawl fishing in the south coast Agulhas Bank region (Wilkinson & Japp 2005a). A study conducted by Wilkinson & Japp (2005a) concluded that there would be a negative impact on the trawl fishery with the development of gas wells in The Blues fishing area on the Agulhas Bank in terms of exclusion zones around the pipelines, eliminating important fishing ground. The overall impact on the fishery was however, ranked as low with localized extent.

Hake longline fishery

Overview

An experimental hake longline fishery was first introduced in South Africa in 1983 (Griffiths *et al.* 2004) targeting both species of Cape hakes. This method of fishing was soon discovered to be highly effective in catching

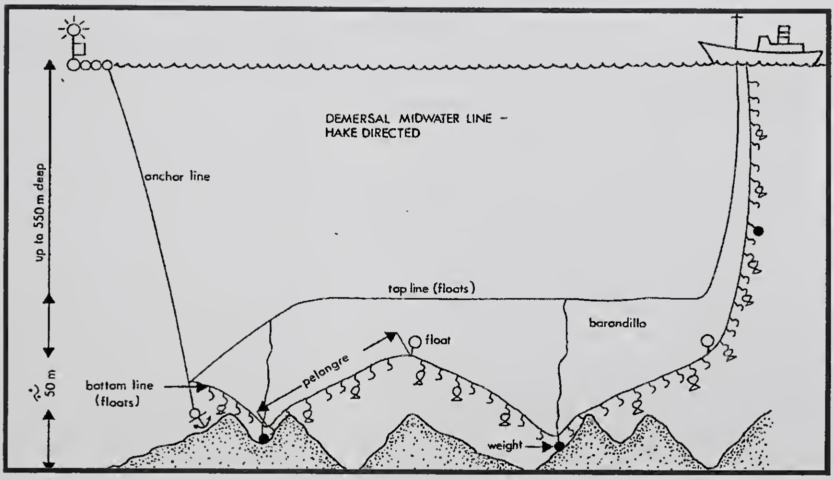

FIGURE 3.4.—Schematic representation of typical hake longline gear configuration (source: D. Japp).

large quantities of the more valued, kingklip (*Genypterus capensis*), resulting in the fishing effort being redirected towards this highly valuable but quota-unrestricted species (Booth & Hecht 2000). By 1986, catch rates of kingklip began to show notable declines and although a maximum limit of 5 000 tons of kingklip bycatch was implemented, catches continued to decline further (Sauer *et al.* 2003). By 1991 all demersal longline fishing was terminated, but in 1994, a hake-directed experimental longline fishery was re-introduced (Fairweather *et al.* 2006). Four-year commercial fishing rights were allocated to the hake longline sector in 2001 (www.seis.sea.uct.ac.za, May 2007). This fishery is managed as part of the 'hake collective' with 10 % of the 'global' hake TAC being shared between hake longline and handline sectors (Fairweather *et al.* 2006).

Hake longline fishing takes place along the west and southeast coasts of South Africa in both inshore and offshore waters. Inshore longlining may only use bottom-set longlines with a maximum of 5 000 hooks deployed per day and no fishing is permitted in tidal lagoons, rivers or estuaries [Permit conditions: hake longline (South Coast Offshore) 2007]. Offshore longlining may only take place in water deeper than 110 m and no more than 20 000 hooks per line are permitted (www.seis.sea.uct.ac.za, May 2007).

Baited hooks are attached to subsidiary lines, stemming from the main fishing line, and are deployed from a hydraulically controlled shoot, located at the stern of the vessel (Figure 3.4.). Floats are attached to the mainline to hold subsidiary lines off the sea floor. These lines can be well over a kilometre in length (Griffiths *et al.* 2004) with each longline set holding an average of 7 500 hooks for the demersal hake longline fishery in South Africa (Petersen *et al.* 2007). Lines are usually set in the early hours of the morning (~ 3 a.m.), left to soak for 5–6 hours after which hauling commences, which can require much of the daylight hours to complete, depending on total length of the line and success of the catch (D. Japp pers. comm.). An average of 8.3 million hooks were reportedly set each year between 2000 and 2004 for this fishery in South African waters (Petersen *et al.* 2007).

Biodiversity impacts

Longlines are considered to be a more selective fishing method than demersal trawl and believed not to cause as much damage to the seabed; however, they are not without their biodiversity and ecological impacts (Griffiths *et al.* 2004). Longline gear can cause localized damage to the seabed and gear loss can result in ghost fishing (J. Barendse pers. comm.). The most serious biodiversity concern, with respect to longline fishing activities, are the incidental mortalities of sharks, sea birds and turtles. Longline fisheries have been deemed responsible for the declining populations and threatened conservation status of several shark, sea bird and turtle species (Petersen *et al.* 2007). Demersal longline fisheries are reported to kill ± 300 sea birds and 400 000 sharks and skates per annum (Petersen *et al.* 2007). Barnes *et al.* (1997) reported on the impact of the demersal longline fishery on sea birds and suggested that some mitigation measures be implemented to reduce this impact.

There is considerable debate between the various hake fishing sectors on the recent declines in hake fishery yields. There is a perception that longline fishing techniques have significantly impacted on the hake resource by exploiting grounds that may previously have served as refugia and through targeting of larger fish. This needs to be considered in context and with an understanding of the pressures on demersal resources from a mature and intensive trawl fishery. Demersal longlining can operate in areas where trawling cannot take place (rocky terrain) and these previously unexploited areas may have had an important role in sustaining hake and other demersal resources. Large catches of kingklip in the initial phases of demersal longlining were testament to the unexploited resources in unfished rocky areas. The kingklip resource was already overfished but the highly directed fishing pressure on spawner stock was an additional unsustainable pressure (Punt & Japp 1994 in Booth & Hecht 2000). The kingklip resource was severely overexploited and drastic measures had to be introduced. Kingklip-directed fishing was suspended and this species can now only be landed as a bycatch. Longlining targets large fish through hook size and as large fish are believed to have a greater reproductive success (Berkley *et al.* 2004), there has been concern that targeting of the larger specimens will result in a disproportionally large reduction of reproductive output. Longlining does select for larger fish but as the trawl quota is far greater than that of the longline sector, more large individual hake are believed to be captured by the trawl fishery overall. There are anecdotal reports of longliners now fishing in deeper water and on soft bottom trawl areas, apparently due to overfishing and declining catches on rough ground, where this fishery used to focus its efforts (I & J trawl skippers pers. comm.).

Issues of conflict

The nature of the hake longline fishery (extensive lines set adrift in the currents) lends itself to a high likelihood of conflict with several other offshore sectors, the largest of which are the hake demersal trawl fishery, the petroleum and the shipping sector (CCA & CMS 2001: vol. 2). The hake longline and demersal trawl fisheries compete for the same resource (demersal fish), in similar areas and conflict over damage or potential damage to gear (CCA & CMS 2001: vol. 2). Longline fishers usually set their gear at night across the depth contours, only hauling in their gear during the course of the following day. Demersal trawlers operate along the length of the contours, most frequently during daylight hours and are thus prevented from trawling while longliners are hauling their gear. The conflict in fishing area has recently begun to increase with longliners reportedly setting with increasing frequency in soft bottom areas and deeper water, such as the areas targeted by trawlers (CCA & CMS 2001: vol. 2). Areas of particular conflict between trawlers and longliners include the Cape Valley and the Butterball area (commercial grid blocks 469 and 505 respectively, I & J trawl skippers pers. comm.). Longline skippers report that there are incidences where trawlers trawl over their gear, ignoring the rule that first skippers on the ground have right of way. This results in loss of gear and can lead to ghost fishing.

There is also a risk that the demersal longline fishery will impact on seismic survey gear used by the petroleum or diamond industries (CCA & CMS 2001: vol. 2). Longline vessels are restricted in their movement abilities whilst shooting and hauling their gear, which, due to the expansive length of the lines (up to 20 km long), can take a substantial amount of time. The demersal longline effort is widely dispersed with fishing occurring on both hard and soft benthic environments. The vessels are often small and communication poor. Demersal longline vessels are likely to unintentionally impose significant disruptions or delays on seismic surveys, simply as a result of their fishing practice.

Demersal shark longline

Declining catches in the tuna longline fishery in the mid 1960s resulted in fishers using longline gear to target hake and kingklip under the guise of shark permits (issued as part of tuna longline fishery). Bycatch limits for hake and kingklip were reduced, resulting in a decrease in effort in the shark longline fishery and in 1998 only 23 permits were issued (decreased from more than 30 permits prior to this). The shark longline fishery previously targeted both pelagic and demersal shark species. However, in 2006, a management decision was taken to include the pelagic shark fishery (blue and mako sharks) with tuna and swordfish management, as the gear used to target these species is similar (see Large and small pelagics below). The shark longline fishery thus became the demersal shark longline fishery which is only permitted to target sharks of the genus *Mustelus* (smooth-hound sharks) and *Galeorrhinus* (soupfin sharks) (DEAT

2005). The vessels used in this fishery are generally smaller than pelagic longline vessels and operate closer to the coast.

The demersal shark fishery is managed with a total applied effort (TAE). However, poor catch rates since 1998 have resulted in a sequential decrease in annual permit holders each year (DEAT 2005). The fishery is seasonal with higher catches during the winter months, and catch-per-unit-effort fluctuates widely. Prior to 2001, catches averaged about 34 tons of *Galeorrhinus galeus*, since 2001, catches have declined to below 20 tons each year and in 2004 only 3 tons were landed (DEAT 2005). In 2001–2002, a stock assessment indicated that the main targeted species, *Galeorrhinus galeus*, was optimally exploited, despite only three longliners operating in 2001 and two in 2002 (DEAT 2005). Six permit holders have been issued with long-term rights (eight years) for demersal shark longlining in 2007 (DEAT 2005). No shark-finning (removal of fins and discard of the rest of the body) is permitted and the use of stainless steel hooks are prohibited (Permit Conditions: Demersal Shark Longline Fishery 2007). Rights holders are not permitted to harvest oceanic sharks including blue, mako, hammerhead, oceanic whitetip and thresher sharks or those on the protected species list which include ragged tooth and white sharks. Furthermore, permit conditions stipulate that rights holders are not permitted to target any species of sharks adjacent to the Wild Coast or along the KwaZulu-Natal coast.

Biodiversity impacts

Sharks are long-lived, apex predators of marine ecosystems, displaying low fecundity, slow growth rates and late maturation, making sharks particularly susceptible to overexploitation (Stephens *et al.* 2000; DEAT 2005). Removal or depletion of shark populations could have drastic, negative effects on functioning of marine ecosystems and these fisheries should be managed with caution.

High bycatch of hake and kingklip in the demersal shark longline fishery is also of concern and bycatch limits are currently in place to restrict targeting of these bycatch species. Further reductions in bycatch limits will be considered in future, if necessary (DEAT 2005).

Issues of conflict

There is some sector conflict between demersal shark longliners and hake handline anglers (overlap in target species) and with inshore demersal trawl (overlap in target area).

Hake handline

Overview

The hake handline fishery was informally conceptualized in the late 1980s when squid and line fish permit holders began exploring other potential resource options on the south coast when catches of these target species were low (Sauer *et al.* 2003). It was, however, only in 2000 that the Minister of DEAT split the management of the handline fisheries into three sectors: tuna pole, traditional line fish and hake handline in response to the overexploited status of the majority of line fish (www.feike.co.za, May 2007). Traditionally, handline fishers have always caught shallow-water hake (*Merluccius capensis*), largely for subsistence use. However, with an international shift in emphasis towards prime quality hake in the early 1990s and the decline in traditional line fish species, handline hake became a commercially (although risky) viable resource (Sauer *et al.* 2003). Generally hake are difficult to catch on a handline as the species largely occurs in deep water. Occasionally, however, cold, bottom water moves onto the continental shelf bringing the hake closer to the coast and accessible to handline fishers, especially in the coastal area between Plettenberg Bay and Mossel Bay along the south coast (Sauer *et al.* 2003). The fishery continued to grow and activity increased in the Port Elizabeth region, with Port Alfred being the eastern-most limit for this sector (Sauer *et al.* 2003). Highly mobile deck- or ski-boats are used to target hake in waters up to a maximum of 100 m, frequently operating overnight or for up to three days before landing the catch at the nearest port or harbour. The mobility of the ski-boats in particular, allow the fishers to operate from landing sites closest to where the fish are reported to occur (www.feike.co.za, May 2007). The fishing gear generally consists of large fishing reels and heavily weighted single monofilament line, baited with pilchard. The relatively low capital investment required to participate in the hake handline fishery, along with the foreign revenue generated, makes this sector appealing for many fishers. Strong currents limit the areas in which handline fishing is conducted. The hake handline fishery has not commenced in the Western Cape region, primarily because the lucrative hake fishing grounds are in deeper waters, too far from the ports for access by deck- and ski-boats.

Handline hake is managed as part of the global hake TAC, with 10 % of the total hake quota shared between handline and longline. At the onset of the handline fishery in the

late 1980s, catches were estimated to be ± 150 tons (Sauer *et al.* 2003; www.feike.co.za, May 2007). The year 1996 saw the start of an increase in hake handline landings, with a total of 1 500 tons reported, increasing steadily to a maximum of 5 500 tons (the TAC for handline) landed in 2001 (Sauer *et al.* 2003). An estimate of 7 000 tons were landed in 2001 (Sauer *et al.* 2003, www.feike.co.za, May 2007) taking into account an average of 30 % under-reporting of the catch. In 2000, the same year that the handline fishery was split from other line fish sectors, a total applied effort (TAE) limitation was implemented for the hake handline fishery (maximum of 130 vessels with 785 crew) with a precautionary maximum catch limit (PMCL) of 5 500 tons (www.feike.co.za, May 2007). Since 2003, the global hake TAC has been decreased by between 2 000 and 4 000 tons, resulting in a decrease in the handline TAC.

Biodiversity impacts

The highly targeted nature of the handline hake fishery results in low levels of biodiversity impact from this fishing sector, although incidental catches of other overexploited line fish species (e.g. sparids) could contribute to further population declines of these threatened species (Japp 2004). Anchoring of deck- or ski-boats can have some level of disturbance and damage impact on the sea floor habitats.

Issues of conflict

A potential for conflict between the inshore hake trawl, longline and hake handline sectors exists (Sauer *et al.* 2003). All three of these fishing sectors generally operate in shallow inshore regions along the south coast and with a decline in availability of hake, territoriality of fishing grounds could develop. Bycatch of line fish in the hake handline fishery is also problematic for line fish stocks, which are mostly overexploited, resulting in cross-sector conflict (Japp 2004). There is also potential for conflict with demersal shark longlining with respect to overlap in target species.

Midwater trawl

Overview

The midwater trawl fishery is defined (according to the MLRA) as ‘any net which can be dragged by a fishing vessel along any depth between the seabed and the surface of the sea without continuously touching the bottom’. Horse mackerel (*maasbanker*), *Trachurus trachurus capensis,* is the target species of the midwater trawl fishery in South Africa. Bycatch species can include many demersal fish (e.g. shallow-water hake) but is largely made up of meso-pelagic species that migrate vertically in the water column and horizontally around the coast, such as chub mackerel (*Scomber japonicus*) and ribbon fish, *Lepidopus caudatus* (Sauer *et al.* 2003). The target species, horse mackerel, are caught in three main fishing sectors:

- Pelagic—inshore purse-seine largely targeting juvenile horse mackerel in the early part of the year along the west coast;
- Midwater directed trawl—focused on the Agulhas Bank near the continental shelf break targeting largely adult horse mackerel;
- Hake demersal trawl as bycatch—largely from the west coast region and seldom exceeding 5 000 tons per annum (Hampton *et al.* 1999).

The horse mackerel fishery in South Africa has historically, never been considered a significant directed fishery, although it has always formed an important bycatch component of the hake trawl fishery (Sauer *et al.* 2003). Between 1950 and 1969 the majority of horse mackerel were landed through the small pelagic fishery with a peak of 118 000 tons in 1954 (Sauer *et al.* 2003). Environmental perturbations observed subsequent to 1969 are thought to have resulted in decreased horse mackerel catches through the pelagic fishery, but were accompanied by a concomitant increase in catches as bycatch in the demersal trawl fishery (Sauer *et al.* 2003). Foreign vessels (largely Japanese and Polish) participated in the midwater trawl fishery in South Africa until 1977, when horse mackerel catches were 94 000 tons (Sauer *et al.* 2003). Subsequent to the declaration of South Africa’s 200-nautical mile EEZ in 1977, foreign fishing effort was largely eliminated and a local midwater trawl fishery was initiated (Sauer *et al.* 2003). The formation of the South African Midwater Trawling Association in 1990 saw the first quotas for this sector issued to nine companies, with the fishery focused on the eastern Agulhas Bank (Hampton *et al.* 1999). The midwater trawl fishery grew throughout the 1990s with the total quota allocations ranging between 17 998 and 27 894 tons (Sauer *et al.* 2003). Limited knowledge of the resource and changing environmental variables strongly influencing the pelagic stocks, have led to the horse mackerel fishery being managed in terms of a precautionary maximum catch limit (PMCL) that has fluctuated between 22 000

and 54 000 tons since 1990 (www.feike.co.za, May 2007). The catch of juvenile horse mackerel by the purse-seine fishery on the west coast of South Africa is limited to 5 000 tons per annum, as a precautionary management measure (Griffiths et *al.* 2004). The remainder of the PMCL originates from the eastern Agulhas Bank region and is largely made up of adult fish.

The Cape horse mackerel is a highly nomadic species with its distributions largely driven by environmental conditions. The shoals are usually concentrated in a small area and migrate seasonally (Sauer et *al.* 2003), greatly limiting this fishery. Juveniles are largely planktivorous, feeding on copepods in the water column near the surface (captured in the pelagic seine-net fishery), whereas adults are opportunistic feeders preying on euphasids, polychaetes, crustaceans and other small fish in the midwater and benthic environs. Horse mackerel and Cape hakes of similar size feed on similar prey items resulting in the potential for interspecific competition between these species (Hampton et *al.* 1999). The midwater trawl fishery is focused on the Agulhas Bank, particularly on the shelf edge on the south and east coasts. It is only in these areas that viable catches of horse mackerel are made (Sauer et *al.* 2003). The midwater trawl fishery is usually operated in conjunction with the hake demersal trawl fishery as the vessel and gear requirements are very similar. Midwater trawl nets are required to be a minimum of 75 mm stretched mesh and usually, vessels carry both midwater and demersal trawl gear, allowing operators to select the appropriate target gear depending on the availability and market price of the fish (Sauer et *al.* 2003). Smaller trawl vessels, such as medium-sized freezers (40–50 m) or wetfish trawlers (30–50 m) frequently have both demersal hake and midwater horse mackerel quotas, targeting horse mackerel when available (Sauer et *al.* 2003).

To gain access into the midwater trawl fishery, a considerable amount of capital investment in the form of a freezer trawler and/or land-based processing facilities is required, hence a further benefit of combining with a demersal hake quota. The horse mackerel fishery on its own has, nonetheless, proved to be viable by utilizing low-cost Eastern-block midwater trawlers, processing large volumes on board and keeping the cost of the catch at a minimum (Sauer et *al.* 2003). The value of the catch is comparatively low (R3.20/kg in 2001) driven by a fluctuating Central and West African market, resulting in this fishery being economically marginal (Sauer et *al* 2003).

Biodiversity impacts

Midwater trawl fisheries tow at a higher speed than demersal trawl and for this reason have higher potential for entanglement of sea birds, sharks, dolphins and seals when near the surface (Nel 2004). Sea birds and small mammals are known to forage on fish escaping from trawl nets and frequently get tangled in the net as it is being hauled (Nel 2004). Sunfish, *Mola mola,* are also known to be captured in midwater trawl nets as bycatch, although currently, very little information exists on the frequency and extent of impact this has on sunfish populations (Nel 2004). The midwater trawl fishery is not considered to have significant impacts on benthic biodiversity, provided the targeted fishery adheres to the definition of midwater trawling by not coming into contact with the sea floor. Fluctuations in abundance of the target species (horse mackerel) are thought to be largely driven by natural environmental variability, similarly impacting on small pelagic species.

Issues of conflict

The midwater trawl fishery overlaps in area in both the demersal trawl fishery and the small pelagics fishery. Potential exists for conflict among these different fishery sectors should the quota holders be exclusive. In most cases, however, small pelagic quota holders also have quotas for juvenile horse mackerel and demersal trawl fishers also have quotas for horse mackerel. This allows switches in the target species when conditions are viable for horse mackerel and limits conflict, as they are essentially the same fishers.

Hake are also caught as a bycatch in the midwater horse mackerel trawl fishery. However, a management measure of reserving 500 tons of the annual hake quota for incidental catches in the midwater fishery has mitigated this potential conflict issue (Japp 2004).

Traditional line fish

Overview

Line fisheries in South Africa include commercial, recreational and subsistence sectors that operate along the entire coast. The commercial linefishery is the only sector addressed in this report. This fishery developed in the western Cape from the fishing activities of European seafarers in the 1500s (Sauer et *al.* 2003). By the mid 1800s the boat-based linefishery had grown into a prosperous industry using sail and row boats. The Cape fishery grew substantially with the construction of

small boat harbours (1932–1950) and fishers switched to motorized vessels. Boat-based commercial line fishing in KwaZulu-Natal (KZN) commenced in the late 1800s, making use of steam-powered deck-boats that operated out of Durban harbour (Penney et *al.* 1999). Over time, these were replaced by diesel-powered vessels between 10 to 35 m long, having a distance range of up to 1 000 nautical miles. Initially, most boats focused their effort on the shallower reefs along the central KZN coast but effort increasingly shifted south, to the former Transkei coast, as the catch rates in the central region declined (Penney et *al.* 1999; Sauer et *al.* 2003). After the Second World War, a number of factors contributed to marked changes in the nature of the commercial line fishing sector in KZN, and later, in the western Cape. The introduction of 4–6 m mobile ski-boats, facilitated launching from beaches and river mouths, which significantly increased fishing access and expanded effort. It also significantly lowered input costs to the fishery so that many more people could enter the fishery (Sauer et *al.* 2003). The number of boats increased from 10 in 1910 to 140 in 1995 in KZN alone (Penney et *al.* 1999). During the 1990s, the average number of active commercial vessels in the western Cape were 577, while in the southwestern Cape there were 986 (Griffiths 2000). The mobile ski-boat was introduced from the KwaZulu-Natal region into the western Cape, where deck-boats had previously dominated, again facilitating the expansion of the fishery. In the mid-1980s, large freezer vessels, subsidized by the squid and tuna industries, were introduced (Sauer et *al.* 2003). The concomitant evolution in line fishing gear, commercial echo-sounders and electronic navigation systems, have continued to contribute to increased fishing effort in the linefishery (Penney et *al.* 1999; Griffiths 2000).

The South African commercial linefishery stretches from Port Nolloth on the west coast to Cape Vidal on the east coast, and therefore includes both cool temperate (west coast) and warm-temperate (east coast) biogeographic regions. Commercial line fishing is only excluded in some MPAs including the Maputaland and St Lucia MPAs, Tsitsikamma, De Hoop and small no-take zones within the Table Mountain National Park. The Cape commercial linefishery consists of about 2 500 vessels (3–15 m long), which operate on the continental shelf (5–130 m depth) between the Orange River in the Northern Cape and the Kei River in the Eastern Cape using handline or rod-and-reel (Griffiths 2000). In KwaZulu-Natal the linefishery is centred in two major fishing areas; a narrow zone of scattered reefs that extends along much of the coast, roughly following the 50 m isobath and deeper reefs (100–200 m) south of Durban and north of the Tugela River (Penney et *al.* 1999). The area from Cape Vidal to Mozambique falls within the St Lucia and Maputaland marine reserves where no reef fishing is allowed. The Cape commercial linefishery accounts for ± 95 % of the South African line fish catch (Sauer et *al.* 2003). Owing to the large number of users, launch sites, species targeted, and the wide operational range, the linefishery is managed on an effort basis, rather than on a catch basis. There are currently about 450 vessels (3 400 crew) operating in the commercial linefishery (C. Wilke, MCM pers. comm.). Bag limits also apply to the commercial component for some species. Line fishers are restricted to a maximum of 10 hooks per line (www.feike.co.za, May 2007). Sauer et *al.* (1997) noted inaccuracies in commercial linefish returns with frequent under-reporting of catches.

Key target species vary by region. Approximately 250 species have been reported in catches, although only 35 species make up the majority of catches. Catches in the Western Cape are dominated by snoek, *Thyrsites atun*, with the catch composition increasing in diversity towards the east. In KZN, target species include both resident reef fish (Sparidae, Serranidae), pelagic migrants (such as Carangidae and Scombridae) and demersal migrants from the south (Sciaenidae and Sparidae) (Sauer et *al.* 2003). Catches have been sustained by sequential targets switching from large endemic reef fish such as seventy-four, red steenbras and rockcods, to smaller sparids such as slinger, santer and trawl soldier (Penney et *al.* 1999). Shoaling migrants such as geelbek, dusky kob and king mackerel have also become increasingly important in sustaining the fishery (Sauer et *al.* 2003).

Most species are severely overexploited (see biodiversity impacts) and a new Line fish Management Protocol (LMP) was developed and endorsed for the linefishery in 1999 (Griffiths et *al.* 1999). The LMP requires management plans for all line fish species to be implemented, and the stock status evaluated, using biologically based stock assessments and historical trends in catch and effort. The LMP and the specific species management plans are the two principle tools used to manage the line fish resource. Line fish regulations, with respect to the MLRA, were officially gazetted in 2005 (Gov. Gazette No. 27453), thereby

legally enforcing the LMP and management plans (C. Wilke pers. comm.). In 2006, a total of 448 long-term fishing rights were allocated for line fish, and for the first time, line fishing effort is managed geographically through implementation of geographical management zones (effort apportionment, C. Wilke pers. comm.). These zones are designated as Zone A: Port Nolloth to Cape Infanta; Zone B: Cape Infanta to Port St Johns; and Zone C: Port St Johns to northern KZN. Vessel Monitoring Systems (VMS) are also required on all line fish registered vessels as part of the new permit conditions for long-term rights.

Line fish comprise the third most important South African fishery with respect to total tons landed and total value. Annual catches prior to the reduction of the commercial effort were estimated at 16 000 tons for the traditional commercial linefishery (www.feike.co.za, May 2007). Almost all of the traditional line fish catch is consumed locally.

Biodiversity impacts

The most recent evaluation of South Africa's marine fish status has indicated that up to 20 species of commercial and recreational marine fish are considered overexploited and/or collapsed (Mann 2000). Since the turn of the century, specialized studies on specific fish species (e.g. scotsman, englishman, belman, carpenter, red roman), further confirm the continued deteriorating status of these species (Mann 2000). Factors contributing to the demise of line fish stocks include increased commercial and recreational fishing effort and inadequate regulations, in conjunction with several life history traits (predictable locality, longevity, late maturity, sex change, barotraumas and estuarine dependence for some taxa) making these species particularly vulnerable to overexploitation (Garratt 1985; Griffiths 2000). There is a problem with serial overfishing of both species and areas (Penney *et al.* 1999; Booth & Hecht 2000). Serial overfishing is the phenomenon where, once fishers have depleted a resident stock, they shift their fishing effort onto another species (Booth & Hecht 2000). This can give the impression of the fishery maintaining stable catch per unit effort (CPUE) and being sustainable when, in fact, fishers are simply shifting their effort onto another species. In addition, fishers serially exploit different areas as highly resident taxa are depleted from heavily fished sites, then move on to previously unfished reefs (Penney *et al.* 1999).

One of the most striking changes in the KZN linefishery was the near-disappearance of the endemic sparid, *Polysteganus undulosus* (seventy four). This species used to aggregate on the Illovo Banks and was rapidly overexploited (Van der Elst & Garratt 1984). The seventy four has been specially protected for the past ten years and its potential recovery is currently under assessment. Species currently considered to be optimally exploited are snoek, *Thyrsites atun,* and yellowtail, *Seriola lalandii* (Mann 2000), carpenter, *Argyrozona argyrozona,* red roman, *Chrysoblephus laticeps,* elf/shad, *Pomatomus saltatrix*, and hottentot, *Pachymetopon blochii*, are some of the species considered to be overexploited, while some of those considered to be collapsed are silver kob, *Aryrosomus incdorus*, white steenbras, *Lithognathus lithognathus*, red stumpnose, *Chrysoblephus gibbiceps,* and slinger, *Chrysoblephus puniceus* (Mann 2000). The status of the fishery of the kob, *Argyrosomus japonicus* and *A. inodorus* is of particular concern (Griffiths 1997a, b). The status of rockcods is also of concern as these slow-growing, resident fish are vulnerable to overexploitation, and poor species identification and multi-species targeting results in poor data for assessing stock status (Mann 2000). The conservation status of some species has been assessed and several species have been red-listed [International Union for the Conservation of Nature and Natural Resources (IUCN 2007-06-18). The endemic white-edged rockcod *Epinephelus marginatus* and the brindle bass *E. lanceolatus* are listed as Vulnerable, whereas the yellowbelly rockcod, *E. marginatus,* is Endangered.

The impact of overfishing reef associated predators (e.g. red steenbras) has not been examined, but their declines may have affected the link between the reef ecosystem and the pelagic food web (Attwood *et al.* 2000). The removal of top predators in rocky reef ecosystems (i.e. line fish) can have far-reaching influences on predator-prey interactions, implications for top predators (sharks and others) and impact on the productivity of reefs (C. Wilke pers. comm.). Anchoring, particularly on deep reefs may cause localized damage to noble corals, black corals, gorgonians and other slow-growing reef biota. There are anecdotal reports of such taxa being retrieved on anchors (K. Sink pers. comm.).

Advances in technology during the past decade have afforded improvements on the range capabilities of small ski-boats most frequently used for line fishing. Since VMS has

become a requirement for all fishing vessels, the operational range for small ski-boats has been quantified to be as far offshore as 40 nautical miles on the Agulhas Bank. Fishermen are now able to target line fish species occupying offshore reef environments (e.g. Alphard Banks). Species of greatest concern on offshore reefs include sharks, red steenbras, red stumpnose and geelbek (C. Wilke pers. comm.).

The Linefish Management Protocol (LMP) implemented drastic reductions in effort and stringent bag limits. However, the life-history traits of most line fish (slow growth, sex change), strong inter-sector competition and ineffective enforcement of regulations continues to contribute to the overexploited status of many line fish species. It is likely that the maintenance of a number of adequately large, well-situated marine reserves offers one of the few practicable options of conserving the endemic fish stocks on the east coast (Penney *et al.* 1999).

Issues of conflict

In the western and southern Cape, the line fish sector conflicts with the inshore demersal trawl fishery as snoek and sparids, targeted by line fishers, are caught in the trawl bycatch, sometimes in substantial quantities (see biodiversity impacts of trawl fisheries). The area of operation of the inshore trawl fishery strongly overlaps with juvenile silver kob (*Argyrosomus inodorus*) nursery areas, resulting in a significant amount of undersized kob contributing to the trawl bycatch (C. Wilke pers. comm.). The legal sale of such trawl bycatch species exacerbates the problems of conflict and pressure on line fish stocks. The squid fishery operates over a large area of the Agulhas Bank along the south coast, which is also favoured by line fishers. The nature of the squid fishery requires the use of bright lights projected onto the surface of the water at night to lure the squid to the hooks. Line fishers have recently expressed concern over the impact that the bright lights may have on line fish, in particular, and other species (C. Wilke pers. comm.). In KZN, the commercial line fishers conflict with the inshore crustacean trawl sector due to line fish contributing a substantial bycatch in the prawn fishery (Fennessy 1994a).

Tuna pole

Overview

Tuna were considered rare in South African waters prior to 1945 and until recently, fetched a relatively low price (Shannon *et al.* 1989). Fishing effort for tuna fluctuated in the 1960s and it was only late in 1979 that a large run of yellowfin tuna (*Thunnus albacares*) sparked renewed interest in the resource and a 115 vessels, including many recreational craft, were hunting tuna by the end of the year. The following year, effort switched to longfin tuna/albacore (*Thunnus alalunga*) offshore when the large shoals of yellowfin failed to appear (Shannon *et al.* 1989). The bait-boat fishery for tuna in South African waters developed in 1980, and by 1990 about 10 000 tons of tuna (predominantly yellowfin tuna) were being caught each year (Hampton *et al.* 1999). Catches subsequently declined to about half (6 571 tons on average between 1993 and 1997), but reached about 8 000 tons again in 1998. The large pelagic longline fishery also targets large bigeye (*Thunnus obesus*) and yellowfin tuna (Hampton *et al.* 1999). In the 1970s tuna were caught by purse seiners on the south coast but as yellowfin shoals were targeted, the permits for this fishery were withdrawn in 1982 (Shannon *et al.* 1989). The tuna pole fishery has undergone many changes in the last four decades, including recent changes in the last five years. Today, the pole fishery in South African waters represents 200 boats, which mainly target juvenile yellowfin tuna. These modern vessels are equipped to catch high quality fish, which are kept in an ice slurry to maintain the quality (J. Hare pers. comm.). Five years ago, most of the pole caught tuna was exported through the longline sector. However, there is now a large, established local market, fuelled by increasing demand for fresh tuna for steaks and sushi.

The South African tuna pole fishery largely operates on the west coast of South Africa, within the 200 nautical mile fishing zone, particularly between 29° and 32°S, targeting the southern Atlantic tuna stock. Tuna stocks occurring in the Indian Ocean on the east coast of South Africa are considered less abundant and thus not fished as frequently or intensely as the west coast (www.feike.co.za, May 2007). Less than 1 % of the tuna pole catch is caught eastwards of the 20°E longitude line. The fishery is seasonal, with catches only occurring between October and June along the west coast. Variations in environmental conditions are known to influence the availability of fish, in some years concentrating them close inshore.

The tuna pole fishery has made use of several types of vessels during the evolution of the fishery. The first were large vessels with onboard freezers, capable of spending substan-

tial periods at sea with a crew of 20 or more. Later, smaller vessels that carried less than 20 crew, spending no more than five days at sea, were more common. In the last five years, more specialized vessels spending shorter periods at sea and storing tuna on ice, are more commonly used (J. Hare pers. comm.). The fishery is not capital intensive, but locating and fishing for tuna using the pole method requires a skilled crew. Water is often pumped from the surface and sprayed alongside the boat to attract tuna. The tuna are then caught with baited hooks or lures and gaffed aboard.

Tuna are opportunistic predators feeding on fish, squid and crustaceans. There are reports of yellowfin tuna foraging on offal from hake trawlers (Shannon *et al.* 1989). Different species of tuna favour different water depths with juvenile longfin tuna (less than 90 cm long) noted for surface feeding in large schools, whereas adult longfin occur lower down in the water column and do not form large schools and are thus not available to the surface gear used by the poling fleet (www.feike.co.za, May 2007). Bigeye tuna are also known to forage over a greater vertical range. These migratory species spawn in more tropical waters. Shannon *et al.* (1989) report that the Cape Point Valley and the Cape Canyon, off Cape Point and Dassen Island respectively, are important tuna fishing areas because of upwelling and the position of the oceanic thermal front close to the coast in these areas. In the 1980s, fishing for longfin tuna was concentrated offshore in the area between St Helena and Lüderitz, with heavy effort outside South Africa's EEZ at Tripp Seamount (Shannon *et al.* 1989).

All tuna species are highly migratory and defined as straddling stocks by the United Nations Fish Stocks Agreement and are thus managed at an international level (see Large Pelagics section). Regional Fisheries Management Organizations (RFMOs) have been established and manage global fish stocks through various commissions (e.g. International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT)). Countries fishing these stocks are obliged to participate in RFMOs which set country quota TACs. However, ICCAT have not yet issued country allocations for the South Atlantic tuna stock. The Department of Environmental Affairs and Tourism currently manage South Africa's Atlantic tuna fishery through a total applied effort (TAE) of 200 vessels carrying a maximum of 3 600 crew (www.feike.co.za, May 2007), mostly targeting yellowfin tuna.

Biodiversity impacts

The tuna pole fishery is a highly targeted fishery with virtually zero unintentional bycatch. The targeted migratory tuna species are observed through international organizations (RFMO). Tunas are considered to be among the top predators of marine ecosystems and can be susceptible to overfishing.

Issues of conflict

Potential for user conflict exists between the tuna pole fishers and the large pelagic longline fishery with respect to overlap in target species and fishing areas, although pole fishers are generally unable to reach the midwater zone that is targeted by longline fishers. Pole fishers attract tuna (usually juvenile yellowfin) to the surface from where they are gaffed into the vessel. Longliners set their lines deeper in the water column targeting the larger, adult yellowfin tuna. The tuna pole sector reports that the Cape Canyon area is critical to their industry, where the tuna follow hake trawl vessels and feed off discards (J. Hare pers. comm.).

Large pelagics

Overview

The South African pelagic longline fishery dates back to the early 1960s, when the fishery targeted albacore (*Thunnus alalunga*), southern bluefin tuna (*Thunnus maccoyii*) and bigeye tuna (*Thunnus obesus*) in a small capacity (Petersen *et al.* 2007). Towards the later 1960s, Japanese and Taiwanese vessels established bilateral agreements with South Africa and fished extensively for tuna and swordfish in South Africa's EEZ (www.seis.sea.uct.ac.za, May 2007). Following the successful outcome from a joint venture between a South African and Japanese vessel in 1995, the South African government issued 30 experimental longline permits to South African flagged vessels in 1997 (Petersen *et al.* 2007) to primarily target tuna. At the inception of this experimental fishery (between 1997 and 1999) swordfish were the most abundant species caught, comprising 70 % of the landed catch (Kroese 1999). The catch composition changed due to local depletion of swordfish and as fleets moved into temperate and offshore waters, more temperate tuna were caught, such that swordfish comprised 21 % of the catch (Govender *et al.* 2002). Increasing pressure from the South African fishing sector to exclude international fishing in South Africa's EEZ encouraged the Minister of Environmental Affairs and Tourism not to renew international fishing agreements with Japan and Taiwan for longline fisheries in 2002.

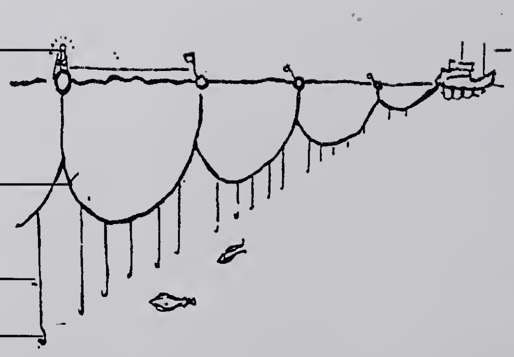

FIGURE 3.5.—Schematic illustration of pelagic longline fishing activity, showing fishing gear deployed in water column ~ 40 m depth (source: D. Japp).

The species targeted by the pelagic longline fishery (tunas, *Thunnus* spp. and swordfish, *Xiphias gladius*) are not confined only to South African waters, are highly migratory and defined as straddling stocks by the United Nations Fish Stocks Agreement. These species can only be managed at an international level through country quota allocations, stock assessments, global TACs and development of compliance and control measures (Japp 2004). For this purpose, Regional Fisheries Management Organizations (RFMOs) have been established, such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). In accordance with the United Nations Fish Stocks Agreement, countries fishing these stocks are obliged to participate in the RFMOs responsible for management of the species in question. Catch (TAC) and effort (TAE) limits for these highly migratory species are therefore set by the RFMOs and in order to secure quotas for such species, South Africa is required to participate and implement recommendations made by these organizations in developing and managing this fishery.

The experimental pelagic fishery in South Africa (1997–2004) provided the country with an opportunity to establish a performance history in the fishery, thus increasing the likelihood of being allocated a country quota for these internationally governed species (e.g. albacore, swordfish and bluefin tuna). The success of the experimental fishery demonstrated that South Africa had the expertise and skill required to fish for tuna and swordfish and in 2005 the sector was formalized into a commercial fishery (C. Smith pers. comm.). Fifty commercial large pelagic, long-term fishing rights were allocated (30 tuna-directed and 20 swordfish-directed), although some of these rights holders employed Asian vessels under joint ventures (Petersen *et al.* 2004). Permit holders primarily target large tuna (bigeye, *Thunnus obesus* and yellowfin, *Thunnus albacares*) for the Japanese *sashimi* market, and swordfish (*Xiphias gladius*) for fresh (iced) export. Many of these vessels fish near the edge of, or on, the continental shelf (~ 200 m depth) , where bycatches of sharks are often also significant (Petersen *et al.* 2004; Sauer *et al.* 2003; see Pelagic Shark longline section).

South African longline fishers are expanding the area in which pelagic longline fishing occurs, as their experience in this fishery increases (Sauer *et al.* 2003). The pelagic fishery strongly follows the 200 m isobath offshore of East London almost to the Orange River border in the north (Sauer *et al.* 2003). Yellowfin tuna and swordfish catch rates are highest in the warmer Agulhas current waters, whereas bigeye tuna tend to be more abundant at oceanic fronts between the Agulhas Current and cooler water, further to the south or west (Sauer *et al.* 2003). More recently, longline fishers are beginning to exploit fishing areas in High Seas that are fished by international fleets from Spain, Taiwan and Japan, e.g. the mid-Atlantic Ridge and Walvis Ridge (Sauer *et al.* 2003).

A variety of fishing vessels are used for the pelagic longline fishery, ranging from converted beam trawlers to chartered longliners, between 30 m and 54 m in length (Sauer *et al.* 2003). In general, vessels fishing in South African waters are rigged with monofilament fishing gear (polyester synthetic fibre) comprised of 20 m long buoy lines and 20 m long trace lines (snoods), to which a hook is attached and baited (Figure 3.5., Sauer *et al* .2003). The trace lines and buoy lines are attached to

the main line by a snap clip (Figure 3.5). Light sticks are frequently attached near the hook when targeting swordfish (DEAT 2002 Policy for tuna longline). The gear is rigged such that the baited hooks are suspended at depths of ± 40 m and are typically deployed at night, being hauled the following morning. The length of the main line ranges between 35–40 nautical miles per set, each having between 750 and 1 500 hooks (Sauer *et al*. 2003).

Pelagic shark longline fishery—soon to be incorporated with the pelagic longline fishery

The pelagic shark longline fishery arose as a consequence of shark bycatch from the pelagic longline fishery targeting tuna and swordfish. Shark species targeted by this fishery are mainly pelagic shark species such as mako (*Isurus oxyrinchus)* and blue sharks (*Prionace glauca*). The pelagic shark longline fishery was managed separately from tuna and swordfish from the early 1990s until 2006. The gear and vessels used in the pelagic shark fishery are very similar to those used in the tuna and swordfish fishery, and the bycatch vs. target species overlapped significantly in these fisheries. Therefore, in 2006, a management decision was taken to manage both sectors as part of the large pelagic longline fishery (C. Smith pers. comm., www.sharklife.co.za, May 2007). This decision was primarily based on the precautionary approach to fishery management with concern for the high level of under-reporting of shark catches by all countries and the illegal trade of shark fins (C. Smith pers. comm.). From 1 January 2006, the pelagic shark license holders were advised to apply for entry into the pelagic longline fishery and the pelagic shark fishery was supposed to cease. No provision was made to score pelagic shark fishers with respect to entry into the longline fishery, resulting in only one successful application from a previous shark longline fishery (C. Smith pers. comm.). A revision of the application and rights allocation scoring process for this sector is currently under way and is expected to be implemented towards the end of 2007. Until this time, however, exemptions have been granted to shark longline fishers who have demonstrated pelagic shark catch performance (C. Smith pers. comm.). This will facilitate the management of sharks caught by longline as part of the bycatch quota for tuna and swordfish longlining.

Biodiversity impacts

The South African pelagic longline fishery targeting tuna and swordfish, is estimated to catch ± 200 turtles and 200 sea birds each year (Petersen *et al*. 2007). The critically endangered leatherback turtle (16 % of the 200 turtles) and the endangered loggerhead turtle (60 % of the 200) are most frequently caught as bycatch in this fishery (Petersen *et al*. 2007). As many as 22 000 pelagic sharks are captured as bycatch in the pelagic longline fishery each year. Species most frequently encountered are blue (84 %) and mako (10 %) sharks (Petersen *et al*. 2007). Interactions between longliners targeting swordfish and killer whales has resulted in concern for these marine mammals that have been chased or shot at to prevent stealing of bait (Govender *et al*. 2002).

Declining catch rates of swordfish (up to 70 %) along the western edge of the Agulhas Bank have resulted in concern for the sustainability of this species in the pelagic longline fishery (DEAT 2002 Policy for tuna longline). The catch rates for swordfish in the South African fishery were relatively high at the inception of the fishery (1997 to 1998) with an average CPUE of 3.4 kg/hook recorded (Kroese 1999). In other areas of the South Atlantic, CPUE rarely exceeds 0.3 kg/hook (Govender *et al*. 2002). CPUE in South Africa has since declined to well below 1.0 kg/hook, as effort reached saturation levels in the main fishing areas (Kroese 1999). The Indian Ocean Tuna Commission (IOTC) has expressed serious concern over the decline in swordfish catches in the south west Indian Ocean (C. Smith pers. comm.). Conversely, the International Commission for the Conservation of Atlantic Tunas (ICCAT) currently considers swordfish in the south Atlantic ocean to be underexploited.

Issues of conflict

Due to the nature of gear deployment in the pelagic longline fishery, conflict has arisen with this fishery and trawl fisheries as well as petroleum exploration surveys (see Hake deep-sea trawl, inshore trawl and petroleum sections). The longline fishery typically sets their lines at night (or early hours of the morning) which then drift with the current over the Agulhas Bank, moving from the shelf edge to the shallower regions (CCA & CMS 2001: vol. 2). The lines can be many kilometres in length, are not readily visible and their movements, being prescribed by the currents, are unpredictable. Entanglement of such drifting longlines with either trawl gear or seismic survey gear has resulted in conflict between these industries (CCA & CMS 2001: vol. 2).

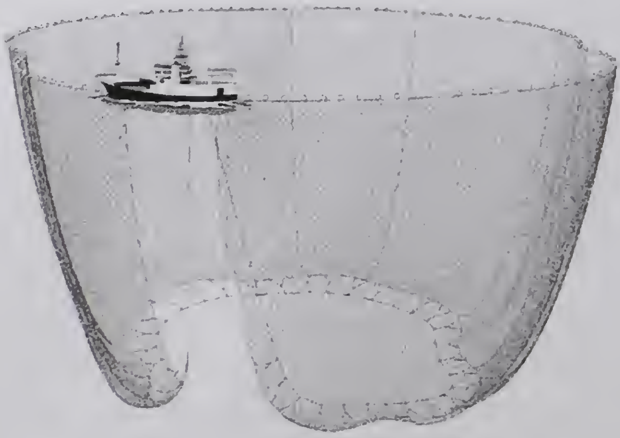

FIGURE 3.6.—Illustration of typical purse-seine gear deployment. The fish are circled and the net pursed and shortened before pumping on board (source: D. Japp).

Small pelagics

Overview

The small pelagic fishery was founded in St Helena Bay, South Africa, shortly after the end of World War II, with fishing activities targeting sardine (*Sardinops sagax*, also known locally as Pilchard) and horse mackerel, *Trachurus trachurus capensis* (Griffiths *et al.* 2004; Sauer *et al.* 2003) using purse-seine fishing techniques. A rapid increase in effort in this fishery resulted in a peak catch of almost 500 000 tons in 1962, 80 % of which was sardine (Crawford *et al.* 1987). Catches of both sardine and horse mackerel declined rapidly after 1962, this being attributed to overfishing and variable recruitment success (Griffiths *et al.* 2004). In 1964, the South African pelagic fishery reduced the mesh size of its nets (from 32 mm sardine mesh to 13 mm anchovy mesh) to target the smaller anchovy (*Engraulis encrasicolus*), this being highly successful, resulting in anchovy replacing sardine as the dominant species of the small pelagic fishery for the next 20 years. Anchovy landings continued to increase until reaching a peak of nearly 600 000 tons in 1988, followed by a 50 % decrease in the catch the following year (Sauer *et al.* 2003). The annual landings of anchovy generally hovered around 40 000 tons thereafter, whereas that of sardine averaged 100 000 tons until 2000. In 2004, sardine catches began to show signs of recovery with landings of 373 000 tons (Hampton *et al.* 1999). Large-scale fluctuations in small pelagic species abundance and distribution are typical of upwelling ecosystems (Griffiths *et al.* 2004).

Adult sardine and anchovy aggregate on the Agulhas Bank during summer where they spawn. Eggs and larvae are transported up the west coast, moving into the productive inshore regions and then migrating southwards, back towards the Agulhas Bank by the following summer (Sauer *et al.* 2003). Anchovy reach spawning maturity after one year. However, sardine only reach spawning maturity after the second year and it has been recommended that they should not be exploited until then (Sauer *et al.* 2003). Adults and juveniles of these two species shoal together making either overexploitation of sardine or under-exploitation of anchovy likely (Sauer *et al.* 2003). Joint management of these species is challenging; however, management cannot be conducted independently. A substantial catch of west coast red-eye round herring (*Etrumeus whiteheadi*) since the 1980s—as much as 76 000 tons in 1995 (Hampton *et al.* 1999)—in the small pelagic fishery, has led to some attempts to target adults of this species along the west coast. This species is believed to be underexploited and an annual precautionary upper catch limit of 100 000 tons is set each year (C. van der Lingen, MCM, pers. comm.). This limit has not yet been reached in this fishery. Another valuable bycatch of the purse-seine fishery is chub mackerel (*Scomber japonicus*). However, targeting of this particular species in the purse-seine fishery, is not considered economically viable.

The purse-seine fishing method aims to target shoals of small pelagic fish visible near the surface at night (Armstrong & Thomas 1989). Once a shoal has been located, the net is set around the shoal with the bottom of the net being pulled closed with a footrope (Figure 3.6.; Armstrong & Thomas 1989). The net is brought alongside the vessel and the fish are transferred into the hold with a suction pump.

The fish are kept in chilled seawater or brine solution until the vessel capacity is reached. The fish are landed at a processing factory where they are again transferred from the vessel hold directly into the factory and processed into fish oil or fish meal (majority of the catch), and canned or frozen for bait (large adult sardine). Most pelagic fishing vessels catch their carrying capacity overnight (average of 200 000 tons) and land their catches early in the mornings, preparing to fish again the following night.

The small pelagic fishery is currently managed through quota allocations at three levels, TAC for adult sardine, a preliminary TAC for anchovy and for sardine bycatch, this being revised after six months and re-allocated. Acoustic surveys conducted in November-December each year estimate the recruitment potential (spawner biomass) for the following year and TACs for sardine are set. Preliminary TACs are also set for anchovy and sardine bycatch, but a second acoustic survey, conducted in May-June each year, estimates the actual recruitment having taken place and this is used to modify the anchovy and sardine bycatch TACs, if necessary (Sauer *et al.* 2003). The adult sardine TAC is not modified after the second survey as the adult fish will have spawned and are not thought to be vulnerable.

The commercial small pelagics fishing industry has historically concentrated on the west coast of South Africa, specifically in St Helena and Saldanha Bay. There is also a substantial pelagic fishery along the south coast, centred around Mossel Bay and Port Elizabeth, targeting juvenile recruits on the Agulhas Bank (Griffiths *et al.* 2004).

The small pelagic fishery is South Africa's highest producing fishery in terms of landed mass and is the second most valuable fishery (Fishing Industry Handbook 2006), worth approximately R800 million per annum (www.feike.co.za, May 2007). Pelagic vessels are either wooden or steel-hulled purse-seiners ranging in length from 11 to 48 m. This is a capital-intensive fishery requiring expensive vessels and specialized equipment with net-replacement costing up to R1.5 million (Sauer *et al.* 2003).

Biodiversity impacts

Purse-seine fishing operations are highly selective and target shoals of fish near the surface of the water column. Only a very small amount of landed bycatch species is not processed. Biodiversity concerns are centred around the important role that these fish play in marine foodwebs. Overfishing and targeting juveniles (especially sardine) in the small pelagic fishery are considered to have substantial impacts on the ecosystem structure and functioning in altering the composition and spatial distribution of these populations (Griffiths *et al.* 2004). Cury *et al.* (2000) also suggests that intense fishing of small pelagic populations can lead to reduced intraspecific diversity. Small pelagic fish are ranked at an intermediate trophic level, but, having large population sizes, exert a top-down control on zooplankton and a bottom-up control of predators (other fish and marine birds). These species play a crucial role in the transfer of energy between upper and lower trophic levels and their abundance can have substantial impacts on the ecosystem (Cury *et al.* 2000). An example of this is shown with the collapse of the sardine stock during the 1960s being followed by a collapse of African penguin colonies along the west coast of southern Africa (Griffiths *et al.* 2004). Small pelagic fish are recognized as important prey for sea birds and there is thus a current initiative to identify and protect important bird feeding areas. Pelagic fisheries would be excluded from these areas (R. Crawford, MCM, pers.comm.).

Issues of conflict

There is potential for conflict in the area targeted for fishing by purse-seiners on the south coast and inshore demersal and midwater trawl fisheries. All three of these fisheries concentrate around the inshore area of Mossel Bay, Plettenberg Bay and Port Elizabeth. Although targeting different species occupying different ecosystem niches, an overlap in fishing grounds may result in conflict. The midwater trawl fishery largely targets adult horse mackerel, while it is the juvenile horse mackerel that shoal with other small pelagics. There is limited species targeting overlap between midwater trawl and small pelagic fisheries. The purse-seine fishery is also frequently accused of overfishing, resulting in declines in sea bird populations (e.g. African penguin and gannets). While this does not result in conflict over target species, there is potential for conflict around quantities and areas fished.

Squid

Overview

The chokka squid, *Loligo vulgaris reynaudii*, has been targeted in South Africa for many years. The history of squid fishing in South Africa is reviewed by Augustyn & Smale (1989). Prior to the development of the jig fishery, chokka squid has featured in the catches of

trawl fisheries and was caught for use as bait by line fishers. In the 1960s and 1970s, the squid resource was heavily exploited by foreign trawl fleets but this was phased out in the late 1970s and early 1980s following South Africa's declaration of the EEZ. However, squid and other cephalopods continued to be taken as bycatch by South African trawlers (200—600 tons per annum, Sauer et *al.* 2003). The South African linefishery for squid developed along the south coast in the early 1980s where spawning aggregations between Plettenberg Bay and Port Elizabeth were targeted.

Loligo vulgaris reynaudii is found between Namibia in the west and the Wild Coast in the east and spawns on the seabed, usually in inshore areas, but is known to spawn in deep water on the Agulhas Bank. Most fishing takes place between Plettenberg Bay and Port Alfred between 20 m and 120 m depth but effort is highest in water shallower than 30 m (Mike Roberts, MCM, pers. comm.).

The linefishery for squid is a jig fishery operated by handlines. Hand-held jigs are used as jigging machines proved unsuccessful (Sauer et *al.* 2003). Squid boats range from small ski-boats (these initially dominated, but few are left in the industry at present) to fairly large deck boats more than 20 m long (Sauer et *al.* 2003). This fishery is somewhat seasonal (main season October—March) targeting adult squid in spawning aggregations. In winter, squid fishing takes place in deeper water where the use of lights is employed. At this time, the squid are dispersed over the entire Agulhas Bank and catches are lower. Stock assessments are conducted on an annual basis (Mike Roberts pers. comm.). Squid is frozen at sea, usually in 10 kg blocks and is considered a high quality export product of international standard. Catches are usually landed at harbours between Plettenberg Bay and Port Alfred. Between 1986 and 1988, a licensing system was introduced with a view to limiting the number of vessels participating in the fishery. The fishery is now regulated in terms of a total applied effort (TAE). Since 1988, the fishery has been closed once a year for four weeks in an attempt to counter the effects of 'creeping effort' (Sauer et *al.* 2003). Creeping effort refers to increased efficiency in catching because of technological advances and increased experience in targeting this species.

In 2005 there were approximately 125 rights holders with 136 vessels and 2 422 total crew active in the fishery (Fishing Industry Handbook 2006). The jig fishery registered its highest catch of ± 12 000 tons in 2003/2004 (Petersen & Nel 2007). Average catches in the 1990s were between 6 000 and 7 000 tons per annum (Roel et *al.* 1998). The abundance of chokka squid fluctuates substantially. The effects of fluctuations in predation, prey availability and the physical environment are quickly reflected in squid stocks due to their short life span (± two years) thus providing little inter-annual continuity (www.feike.co.za, May 2007). Presently, chokka squid abundance is at near-record high levels, but experience suggests that substantial declines can be expected (Petersen & Nel 2007).

In 2002, when the South African Rand was at its lowest level against major international currencies, the price of squid rose to almost R50 per kg. The average price of squid in 2004 was R30 per kg. The chokka squid fishery provides employment for ± 3 000 people, including land-based personnel. The landed catch is worth more than R180 million per year. The squid jig fishery makes a significant contribution to the economy of the southeastern Cape coast region.

Biodiversity impacts

The squid jig fishery has relatively little impact on other species and this fishery is considered to have very low impacts on biodiversity overall (Petersen & Nel 2007). Benthic habitats are not damaged and bycatch is negligible. There is concern about potential trophic impacts on squid predator populations (seals, line fish, cetaceans, sharks and sea birds). Plastic pollution from squid boats has also been raised as a concern. Some concern has been expressed by the linefishery that the use of lights could have negative impacts on marine ecosystems and there has been a recommendation to reduce the intensity of lights used in this fishery (C. Wilke, MCM, pers. comm., www.feike.co.za, May 2007).

Squid licensed vessels have been reported to illegally harvest squid from within the boundaries of the Tsitsikamma Marine Reserve (Lemm & Attwood 2003).

Issues of conflict

This fishery has experienced conflict with the demersal trawl sector who occasionally also target squid (Sauer et *al.* 2003). Squid eggs are vulnerable to anchor damage from line fishing and other boats (Sauer 1995).

Coastal residents sometimes complain about the brightness of the lights used by squid fishers at night. This effect on other commercially

important species and the marine ecosystem in general, is not certain. However, some concern has been raised by line fishers over this potential impact.

Crustacean trawl

Overview

South Africa's crustacean trawl fishery is confined to the province of KwaZulu-Natal (KZN) although this fishery extended into southern Mozambique in the 1970s and early 1980s. During this time, South African, Spanish, Soviet and East German trawlers targeted deep-water prawns, langoustines and rock lobsters in the area (De Freitas 1989). The fishery began in the 1970s with sporadic fishing between 1976 and 1983, after which, a well-organized fleet began more intense commercial operations (De Freitas 1989). Initial effort in KZN was focused on deep-water rock lobsters (*Palinurus delagoae)* and anecdotal reports indicate that during the early years of the fishery, only rock lobsters were retained, with the remainder of the catch being discarded (Tomalin 1988; Forbes & Demetriades 2005). The potential inshore prawn resource was known by fishers but they preferred to target more lucrative species in deeper water and had also experienced net damage due to tree debris on the Tugela Banks (De Freitas 1989). Inshore prawn trawling began in earnest in 1983 but sporadic fishing took place on the banks since 1976. The inshore and offshore fisheries are separate sectors that target different species, in different areas, using different gear.

The inshore crustacean trawl fishery operates primarily in water 20–45 m deep and is confined to the area within 0.5 to 7 nautical miles of the shore (Fennessy 1999). The Tugela Bank is the primary inshore trawl area, a shallow area between Shaka's Rock and Mtunzini where the continental shelf widens and the bottom is characterized by muddy sediments. Other more recently discovered inshore trawl areas include areas off Richards Bay and St Lucia. The environmental conditions of these inshore areas are similar to that of estuarine environments with murky turbid water, high concentrations of food and shelter from strong currents. These conditions are suitable for penaeid prawns and also serve as nursery areas for juvenile fish that take advantage of the good food supply and can avoid predators in the murky water. Inshore trawling is seasonal, with summer catches off St Lucia and effort concentrated on the Tugela Bank from March to August (Fennessy 1999).

The inshore fishery targets white prawns, *Fennereopenaeus indicus*, brown prawns, *Metapenaeus monoceros*, tiger prawns, *Penaeus monodon* and bamboo prawns, *Marsupenaeus japonicus,* on the shallow-water mud banks (Forbes & Demetriades 2005). These prawn species grow fast and have a life-span of ± one year. Penaeid prawn fisheries are dependent on estuarine habitats. Prawn larvae enter estuaries where they grow into juveniles and then move out of estuaries and recruit onto the mud banks, where they mature and reproduce (De Freitas 1989). The inshore trawl catch ranges between 17—122 tons per year (Forbes & Demetriades 2005). Targeted species constitute about 20 % of the catch by mass, with ± 10 % retained bycatch, and 70 % discarded bycatch. Bycatch includes other crustaceans, cephalopods, line fish such as grunter and kob, elasmobranchs and turtles. Retained bycatch includes Tugela swimming crab, *Portunus sanguinolentus*, octopus, squid, cuttlefish, and line fish. The average amount of bycatch discarded has been reported as 400 tons per year (Fennessy 1994a). The predominance of squaretail kob, *Argyrosomus thorpei (*an important line fish), in trawl catches, led to the closure of prawn trawling on the Tugela Bank in late summer. At one stage, spotted grunter (*Pomadasys commersonnii*) caught as bycatch, could be sold but this led to targeting of this important line fish and was subsequently banned (Forbes & Demetriades 2005). There are ± 10 000 sharks and rays caught per year as bycatch in the prawn trawl fishery (Fennessy 1994a, b) and this is of great concern for biodiversity. Prawn abundance fluctuates with rainfall (Fennessy 1999) and the recent reduction in inshore catches could be linked to the drought in the area and prolonged closure (five years) of the St Lucia estuary. Catchment developments, particularly forestry and agriculture, threaten the nursery role of the estuarine systems that support the inshore prawn fishery in South Africa.

The deep-water crustacean trawl fishery operates offshore, on the edge of the continental shelf in water 100–600 m deep from Port Edward to Cape Vidal. Offshore permit holders may not fish within seven nautical miles of the shore in the area between Cape St Lucia and Greenpoint (this excludes the Tugela Banks and inshore trawl grounds off Richards Bay, Mtunzini and Durban). Approximately 350 tons of catch are landed annually with 1 700 tons of bycatch (Fennessy & Groeneveld 1997). This fishery targets langoustines, *Metanephrops andamanicus* and *Nephropsis stewarti*, pink prawns *Haliporoides triarthus* and Natal deep-water rock lobster, *Palinurus delagoae*

(Sauer et *al.* 2003). Considerable quantities of the East coast red crab, *Chaceon macphersoni,* are also retained. Pink prawns, langoustine and red crab are found mostly at depths greater than 300 m, whereas rock lobsters occur mainly in the 100 to 300 m depth range (Groeneveld & Melville-Smith 1995). Slipper lobsters (*Ibacus novemdentatus* and *Scyllarides elizabethae*) also constitute a component of the retained bycatch. The offshore crustacean species are probably slow-growing, with a slow population turnover and are therefore vulnerable to overexploitation (Sauer et *al.* 2003). Retained teleosts include longfin kob, deep-water hake (*Merluccius paradoxus*), greeneyes (*Chlorophthalmus punctatus*) and john dory (*Zeus* spp., Sauer et *al.* 2003). Small quantities of jacopever (*Helicolenus dactylopterus*) and bluefin gurnard (*Cheilidonichthys kumu*) are also retained. The cephalopod bycatch includes deep-water octopus (*Veladona togata*) and cuttlefish (*Sepia officianalis,* Sauer et *al. 2003*). The discards of the offshore fishery have not been formally investigated, but are thought to comprise about 70 % of the total catch (Fennessy & Groeneveld 1997). Fishes that are currently not marketable, such as grenadiers (rat-tails), dominate the discards, followed by crustaceans, asteroids and mollusks, having no commercial value (Sauer et *al.* 2003).

The KZN prawn trawling industry uses vessels 24 to 40 m in length and generating 500–1 000 horsepower (Sauer et *al.* 2003). The trawlers mostly use single otter trawls deployed from the stern, although vessels with two beams deploying two nets, have also been in use and triple nets are not excluded. Trawl net sizes range from 25–72 m footrope length, with a minimum of 50 mm mesh size measured from knot to knot, specified in the 2007 permit conditions. 'Tickler' chains, attached to the footrope, are used to disturb the prawns when trawling, causing them to leave the substratum (Forbes & Demetriades 2005). Heavy doors or booms keep the net spread open and buoys are used to keep a headline afloat, whereas a weighted footrope is used to position the net as it is dragged along the seabed (Fennessy 1999). Trawl speeds are between two and three knots and the average drag duration is four hours. The trawlers can stay out at sea for three weeks and have a crew of 12–20 men. Catches are size-sorted, graded, packed and blast-frozen at sea. Catches are landed at Richards Bay or Durban harbour. Effort levels in the Tugela Bank prawn fishery have been variable over the years, being determined by a variety of factors such as prawn abundance (influenced by drought), seaworthiness of trawlers and liquidation/change of ownership of trawling companies (Fennessy 1999).

The fishery is managed using a total applied effort strategy (TAE) limiting the permitted number of vessels. A TAE of seven fishing permits has been enforced, reducing the maximum number of fishing permits over the past ten years, by one (www.feike.co.za, May 2007). Fishing on the Tugela Bank is prohibited from September to February to protect kob. The sector is capital-intensive and its infrastructure, marketing and product distribution are dominated by established companies.

Value

The landed catch in the KZN prawn fishery is worth ± R21 million per annum (www.feike.co.za, May 2007). Although the fishery is small in terms of numbers of vessels (eight) and total retained catch (~350 tons), it is of considerable local importance, both economically and socially (Sauer et *al.* 2003).

The fishery may be only marginally economically viable, hence over-allocation of effort may reduce catch per vessel and therefore revenue (Sauer et *al.* 2003). This is the opinion of one of the companies that has been operating in KZN for several years. The economic information supplied by the permit-holding companies seems to support this assertion, with net annual profit before tax, being in the region of R250 000 for a typical vessel worth R5 000 000, and with fixed and operational costs of R5 000 000 per year.

Biodiversity impacts

The crustacean trawl fisheries have potential impacts on their target species, on bycatch species and on the soft-sediment and shelf edge habitats where they trawl. Stock assessments of targeted prawns have never been undertaken and no studies of benthic impacts of crustacean trawling have taken place. Little is known about the biology of the deep-water prawns and langoustines but the deep-water crustaceans are slow growing and the lobsters are likely to be vulnerable to overfishing, particularly in trawl fisheries (Berry 1969; Pollock 1989). Preliminary assessments for langoustines and pink prawns in 1997 indicated that langoustines were unlikely to be biologically overexploited at current levels of effort, while further analysis on stock-recruit relationships was required before changes in effort for pink prawns could be recommended (Tomalin 1998 cited in Sauer et *al.* 2003).

There are only three main areas that provide significant habitat for the inshore prawns in South Africa; the Tugela Bank and areas off Richards Bay and St Lucia. The inshore prawn habitat type is not currently represented in any MPAs. At present, trawling is not taking place off St Lucia (probably due to the drought) but commercial prawn trawling is not prohibited. Forbes & Demtriades (2005) reported that the continuation of trawling off the St Lucia Estuary mouth should be carefully considered, as although current knowledge is limited, the fauna of this area are very different from the Tugela Bank, and the trawl grounds fall within the Greater St Lucia Wetland Park World Heritage Site (Sauer et *al.* 2003). The offshore sector operates in an area where biodiversity is poorly audited and representative shelf habitats may or may not be included in the greater St Lucia Wetland Park. There is concern that demersal trawlers could be causing habitat damage including shelf slides and slumping. The bycatch of the crustacean trawl fisheries, particularly in nursery areas, is the greatest biodiversity concern at present. Prawn trawling is one of the global fishing sectors with the highest discarded catch, accounting for one third of the global discarded catch (Alverson et *al.* 1994). Subtropical demersal communities are species rich and endemic and other elasmobranchs, teleosts and invertebrates feature in trawler bycatches on the Tugela bank (Fennessy 1994a, b, 1995, 1999) and the offshore sector (Sauer et *al.* 2003). Offshore, elasmobranchs and unique faunal assemblages on the slopes are potentially very vulnerable (Stevens et *al.* 2000). Aside from the considerable bycatch, the impact of inshore prawn trawling on nursery habitats is also of considerable concern. The area offshore of St Lucia is a spawning area for spotted grunter, Natal stumpnose, perch and mullet and serves as a nursery area for many species of teleosts, elasmobranchs and invertebrates (Wallace 1975; Whitfield 1998; Hutchings et *al.* 2002). These species do feature in prawn trawl catches. Fennessy (1994a, b) reported 26 elasmobranch species in trawl bycatches with large discards of newborn scalloped hammerhead sharks, *Sphyrna lewini,* by prawn trawlers on the Tugela Bank. Catches for this species range from an estimated 3 288 sharks in 1989 to 1 742 in 1992 (Dudley 2003). It is unknown whether the Tugela Bank is the only nursery ground for *S. lewini* off the South African east coast. If this is the case, the impact of the prawn trawlers on this species may be substantial. Sharks and rays appear to be particularly vulnerable to overexploitation because of their K-selected life-history strategy (Stephens et *al.* 2000). The ecological consequences of this bycatch are difficult to assess but it could have significant impacts on ecosystem function.

A recent proposal by the Oceanographic Research Institute (ORI) recommends that trawling on the Tugela Bank only be allowed from March to August, which would further reduce trawl-induced mortalities of *S. lewini*. The use of bycatch excluders is under investigation by the Oceanographic Research Institute. The excluder device, a square mesh panel, significantly reduced quantities of discarded catch, but the effect on losses of target species (prawns) could not be adequately assessed, owing to the timing of the sampling trip (S. Fennessy, ORI, pers. comm.). The project proved to be logistically difficult to undertake, owing to a shortage of suitable trawlers to conduct experimental trawling. The square mesh panel may, however, hold promise in reducing discarded catches by prawn trawlers, but further research may be required to refine its application (Sauer et *al.* 2003).

Inshore trawlers that fish close inshore at night run the risk of running aground, which can have severe biodiversity impacts through pollution and can result in loss of human life. This has happened on at least three occasions in recent years (Sauer et *al.* 2003).

Issues of conflict

Conflict exists between the commercial and recreational line fish sectors and the inshore prawn trawl sector. There is a perception amongst ski-boat anglers that inshore trawlers are responsible for their poor catches. Investigations of the Tugela Bank bycatch showed that there was little overlap in line fish and trawl catches with the exception of squaretail kob, *Argyrosomus thorpei* (Fennessy et *al.* 1994a; Fennessy 1999). The Tugela Bank has a closed season that was introduced to protect juveniles of this species.

West coast rock lobster (offshore)

Overview

The west coast rock lobster fishery in South Africa, targeting *Jasus lalandii*, is considered to be one of the oldest fisheries of the country, dating back to at least 1875 when the first commercial processing plant was established (Griffiths et *al.* 2004). During the earlier part

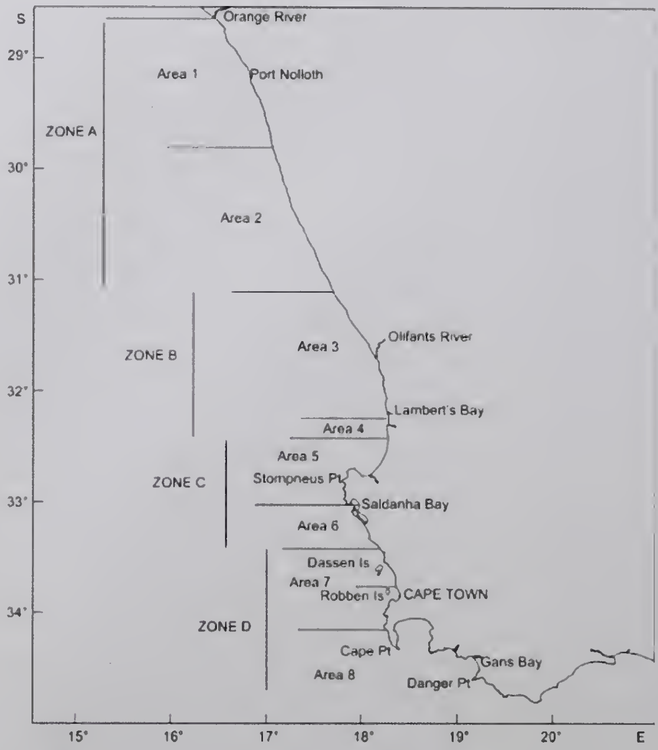

FIGURE 3.7.— Fishing zones for West Coast rock lobster, Jasus lalandii (source: Sauer et al. 2003).

of the 1900s, the west coast rock lobster commercial fishery expanded with catches peaking in the 1950s at ± 16 000 tons (Griffiths et *al*. 2004). In 1946, the first management strategy for rock lobster was implemented with an annual quota being set and a minimum legal size limit of 89 mm carapace length (CL). Other management measures introduced included prohibition of landing berried females or soft-shelled lobsters, a closed season during winter months, and a daily bag limit for the recreational sector (Sauer et *al*. 2003). Towards the late 1960s, catches began to decline substantially and quotas could not be filled (www.feike.co.za, May 2007). The annual TAC was reduced to between 4 000 and 6 000 tons, providing some stability to the fishery until 1990. During the 1990s a decrease in growth rate and poor recruitment, further reduced total rock lobster landings (Cockcroft & Goosen 1995; Cockcroft 1997), with the TAC being reduced to around half of what it was in the 1980s (Griffiths et *al*. 2004). The reduced growth rate severely impacted on the rock lobster resource, further prompting a reduction in legal carapace length from 89 mm to 75 mm CL (Sauer et *al*. 2003). The annual commercial TAC and landings have continued to decline in subsequent years, indicating that the high landings during earlier years were simply not sustainable (Griffiths et *al*. 2004).

The South African rock lobster resource is currently estimated to be at 5 % of pre-exploitation levels (the biomass > 75 mm CL) and the spawning biomass at 20 % of pristine levels (Pollock et *al*. 2000). The resource is considered to be in a stable state. However, it is currently managed in terms of precautionary management principles (Griffiths et *al*. 2004; www.feike.co.za, May 2007). The TAC allocated for the 2006/2007 fishing season is 2 556 tons with an additional 320 tons allocated for recreational fishers (P. Foley pers. comm.). Of the total TAC allocated, the harvest of 1 996 tons is targeted from offshore regions, while the remaining quota is allocated to near-shore regions (P. Foley pers. comm.).

The west coast rock lobster resource is primarily managed by means of annual quotas allocated for the large-scale commercial sector (offshore fishery mostly using traps), an inshore small-scale commercial fishery (previously considered to be subsistence, using hoopnets) and a recreational fishery. The offshore sector is allocated 80 % of the TAC while the remaining 20 % is allocated to the near-shore fishery, reflecting the distribution patterns and abundance of the target species (www.feike.co.za, May 2007). Within the context of offshore marine environments and resources pertinent to this document, only the offshore west coast rock lobster fishery will be detailed.

The commercial offshore west coast rock lobster fishery quota is apportioned into fishing zones stretching from the Orange River mouth to east of Cape Hangklip in the southeastern Cape (inshore), which was allocated an annual quota in 2003. The offshore sector operate in zone B (from the mouth of the Brak River to just south of Lamberts Bay), zone D (just north of Dassen Island to Cape Hangklip), and zone E (southwards from the lighthouses at Cape Point and Cape Hangklip, see Figure 3.7, Permit Conditions 2006/2007 DEAT). The offshore trap fishery largely operates in waters between 30 and 100 m depth and is confined to the west coast of South Africa.

The offshore rock lobster fishery mostly takes place in waters deeper than 30 m, thus restricting the use of hoopnets in this fishery. This sector largely makes use of traps which consist of rectangular metal frames covered by polyethylene netting with a top or side entrance and baited with fish (e.g. pilchard). The traps are deployed from vessels ranging in length between 6 and 14 m, using power winches to haul in the traps. The mesh size of the netting is restricted to allow the escape of undersized rock lobsters. Traps are usually set at dusk and retrieved in the early morning and the catch landed during the day at the nearest port or harbour.

The rock lobster fishery is considered the third most valuable fishery to South Africa with the catch value being approximately R200 million per annum (www.feike.co.za, May 2007).

Biodiversity impacts

The sustained increase in rock lobster abundance east of Cape Hangklip for more than a decade (Tarr *et al.* 1996; Mayfield & Branch 2000) prompted quotas to be allocated to the inshore commercial sector in this area in 2003. Experimental fisheries for five years prior to this had shown that small quotas (200 tons) in this area were economically viable. However, the long-term impacts on the ecosystem are uncertain and the fishery, especially in this zone, continues to be closely monitored.

West coast rock lobsters feed on a wide range of prey items including molluscs, sponges, sea urchins and other crustaceans mostly associated with rocky subtidal reefs. The majority of rock lobster fishing grounds are located on or adjacent to rocky reef structures where the trap lines are set. The traps are large and heavy and if set on high profile, sensitive reef structures, could cause damage by dislodging organisms and damaging reefs. No known studies have been conducted to investigate the impact of rock lobster traps on benthic biodiversity associated with rocky reefs in rock lobster fishing grounds.

The slow growth rate and decrease in abundance of large individual rock lobsters throughout the fishing grounds may have ecological consequences to benthic communities, particularly relating to shifts in dominant species. The extent and implications of these changes are however, largely unknown (Griffiths *et al.* 2004).

Issues of conflict

The rock lobster fishing industry has previously expressed concerns about the impacts of marine mining on the west coast rock lobster resource. However, this is largely restricted to the inshore rock lobster fishery of the Namaqualand coast (Penny & Pulfrich 2004). There is apparently no overlap in operating area between the rock lobster sector and the recently commenced offshore mining operations in this region (Roos 2005).

South coast rock lobster trap fishery

Overview

The south coast lobster fishery targets the endemic deep-water rock lobster, *Palinurus gilchristi*. This species occupies areas of rocky seabed in the 90–200 m depth range between Cape Point and East London (Pollock 1989; Groeneveld & Branch 2002). Such habitats cannot be trawled and fishing is conducted using traps set on long-lines. The south coast rock lobster fishery began in 1974 (Pollock 1989) but declining catch rates were experienced at the end of that decade. Many local fishing boats withdrew from the fishery as catches and catch rates collapsed between 1979 and 1981 (Pollock & Augustyn 1982). In 1972, the landed catch was 2 092 tons (whole mass) but this had dropped to a mere 262 and 368 tons in 1980 and 1981 respectively (Sauer *et al.* 2003). A reduction of effort and catches during the early 1980s allowed the resource to recover, and in 1984 an annual total allowable catch (TAC) of 450 tons tail mass (980 tons whole weight) was introduced. The TAC and restricted entry into the fishery stabilized the sector at a TAC of ± 1 050 tons whole lobster until the 1993–1994 season (Sauer *et al.* 2003). Between 1989 and 2001, the resource had declined by 65 %, largely due to

overfishing by specific companies (www.feike.co.za, May 2007). In 2002, a conservative TAC was set at 340 tons tail mass (755 tons whole mass), combined with a TAE of 1 922 sea days. By 2005, the TAC was increased to 382 tons (848 tons whole mass), combined with a TAE of 2 089 sea days (Fishing Industry Handbook 2006).

Adult *Palinurus gilchristi* are found in commercial quantities at two locations; on the Agulhas Bank (± 200 km offshore) and in an area between Mossel Bay and East London (2–50 km offshore) (www.feike.co.za, May 2007). The inshore area between Danger Point and Cape Agulhas is an important settlement area for juveniles, which migrate to adult habitats further offshore (Groeneveld & Branch 2002). Rock lobsters that occur between Port Alfred and East London are generally smaller, slower-growing and apparently do not migrate (Groeneveld & Branch 2002).

Vessels used to target south coast rock lobster are large steel-hulled ocean-going fishing boats (30–60 m long) specifically rigged for longline trap-fishing (Sauer *et al.* 2003). Each boat operates with 2 000–6 000 barrel-shaped plastic traps, that are tied to longlines in sets of 100–200 traps, with a line of traps being 2–3 nm long. As many as 12 lines are set daily (Pollock 1989). The traps are usually stacked in a large holding pen and vessels are equipped with a powerful line-hauler to haul lines and retrieve traps, and one or two chutes for setting the gear. Catches are processed on board and may be frozen and packed or kept in live fish-holding facilities (Sauer *et al.* 2003). The vessels usually carry 28–35 crew and remain at sea for 2–16 days at a time in the case of live lobster boats (depending on the proximity of the fishing grounds to the harbour) or 28–40 days at a time in the case of freezer boats (Sauer *et al.* 2003). Boats are at sea for 180–300 days per year. In 2006, a total of 16 rights holders were granted access to the south coast rock lobster fishery but this only consisted of 8 vessels. There are more rights holders than vessels in the fishery as some vessels (or catching companies) catch for more than one rights holder on the basis of vessel hire or joint venture agreements (Sauer *et al.* 2003). Fishing takes place year-round (1 October to 30 September) and is managed by a combination of an effort (TAE) and quota (TAC) strategy.

No minimum size limit is enforced and rock lobsters of ± 60 mm carapace length upwards are retained by the fishery. Little protection is thus afforded to breeding females (being sexually mature at ~ 70 mm CL, Groeneveld & Melville-Smith 1994) and a conservative TAC has been set each year since 1984 in an attempt to protect sufficient breeding adults to ensure adequate egg production and recruitment. Female rock lobsters in berry (having eggs) are not permitted to be retained by the fishery.

Biodiversity impacts

The target species of this fishery may be vulnerable to overfishing. The species is slow growing and occurs in low densities (Pollock *et al.* 2000). Incidental bycatch of this fishery is largely dominated by octopus (*Octopus vulgaris*), which are marketed, and a small amount of kingklip and slipper lobster (*Scyllarides elisabethae*, Japp 2004). Lost traps, resulting in ghost fishing and pollution of the ocean, are occasionally reported (Japp 2004). Rock lobster traps may also cause localized physical damage to benthic invertebrates such as corals, gorgonians and sponges, but this has not been investigated (Japp 2004). The smaller plastic traps used by this fishery are likely to have less physically damaging impact than the larger steel cages used in other lobster fisheries.

There have been occasional reports of whales becoming entangled in rock lobster trap lines.

Issues of conflict

A task group was developed at Marine and Coastal Management to deal with entanglement of whales in lines, particularly rock lobster trap lines (A. Cockcroft, MCM, pers. comm.).

Experimental Natal deep-water rock lobster

Overview

The Natal deep-water rock lobster *Palinurus delagoae* was reported to be found in muddy and sandy habitats in the 180–300 m depth range (Pollock 1989; Berry 1971). Two series of experimental deep-water rock lobster fisheries, targeting *P. delagoae*, have been conducted in KZN, with the most recent currently in progress. The first experimental fishery for this species, in the period 1994–1997, suggested that the fishery potential for this species in South Africa was low due to scarcity of suitable habitat and declining catch rates. There was a marked decline in the abundance and size of lobsters caught over the period of the experiment (Groeneveld & Cockcroft 1997). A second three-year experimental fishery for Natal

deep-water rock lobster commenced in 2006 and is entering its final year of operation, after which it will be re-evaluated for entry as a commercial fishery. The experimental fishery uses baited traps or pots set along longlines, as described for the south coast rock lobster fishery.

Biodiversity impacts

The target species of this fishery is likely to be vulnerable to overfishing (Pollock 1989; Groeneveld & Cockcroft 1997). An almost 50 % decline in the abundance index and a marked decline in mean lobster size during experimental fishing is cause for concern. Despite these results published in 1997, experimental fishing has persisted into 2007. There have been reports of high rates of trap loss in this fishery and ghost fishing is a concern (Lombard *et al.* 2004). Some of the habitat occupied by this species is protected within the Maputaland and St Lucia marine reserves but experimental fishing across the submarine canyons and shelf at the boundary of the marine reserves, renders most of the habitat vulnerable to fishing impacts. Bycatch species of this fishery includes slipper lobsters (*Ibacus* sp. and *Scyllarides elizabethae*) (Groeneveld & Cockcroft 1997), red crabs (*Chaecon macphersoni*), spider crabs, elasmobranchs and sparids such as *Chrysoblepharus coeruleopunctatus* (blueskin) (K. Sink pers. comm.).

Conflict

This fishery has experienced conflict with recreational users in the Greater St Lucia Wetland Park. At the onset of the fishery, dive operators cut trap lines and removed marker buoys just outside the Maputaland Marine Reserve. This exacerbates trap loss and has potentially serious consequences, increasing the amount of ghost fishing through these 'lost' traps. The lost traps also cause plastic pollution.

Exploratory fishing

The Department of Environmental Affairs and Tourism (Branch: Marine and Coastal Management) has identified priority in development and diversification of existing fisheries and establishment of new fisheries (DEAT 2004 New Fisheries Policy document). The Department of Environmental Affairs and Tourism's New Fisheries Policy document (2004), defines a new fishery as 'a regulated fishery that exploits a resource or part of a resource that has not previously been managed by the state as a commercial fishery'. This includes:

- previously unexploited resources;
- underexploited resources that contribute as bycatch in another fishery;
- fully/overexploited resources that have not been subject to any management controls.

Motivation for establishment of a new fishery may be explored where a resource shows potential for development, although the required experimentation and research does not guarantee that commercial access will be granted. Development of new fisheries in South Africa requires adherence to an operational protocol, consisting of three phases, namely:

- 1, information gathering—including desktop study, exploratory fishing, economic feasibility, experimental design and Fishery Management Plan;
- 2, implementation of the experimental fishery—including fishery implementation, data collection and monitoring, independent research, assessment of the fishery and finally, ministerial decision on approval/prohibition of further commercial exploitation;
- 3, commercial fishery—including revision of the Fishery Management Plan, allocation of commercial fishing rights, knowledge and skills transfer, monitoring, and further ongoing independent research (DEAT 2004 New Fisheries Policy document).

During the first phase of information gathering, the applicant is required to identify potential environmental impacts the fishery may result in, specifically, disruption of habitat and/or the ecosystem (DEAT 2004 New Fisheries Policy document).

A five-year experimental fishery for **octopus** (*Octopus vulgaris*) has been under way since 2004 when fifteen experimental permits were allocated for specific catch zones along the coastline (G. Maharaj, MCM, pers. comm.). This fishery is restricted to inshore rocky reef areas around the coast and does not influence offshore marine users. Fishers have experienced some difficulties in success in this fishery due to substantial trap loss, low catch rates and conflict with other fishing sectors accessing resources in similar areas. Up to half the allocated permit holders have not engaged in the fishery and their licenses are in the process of being revoked (G. Maharaj, MCM, pers. comm.). The experimental fishery will continue with reduced permit-holders for the remaining experimental period, after which it will be reviewed for commercial status.

An application for an experimental fishery for the **plough whelk** (*Bullia levisima*) is currently

pending but is expected to be granted during the course of 2007. This fishery, operated through the use of hoopnets from small vessels, would be located close inshore in the Western Cape region, having an anticipated bycatch of the three-spot swimming crab. This experimental fishery is unlikely to impact on offshore marine regions.

A new experimental fishery for east coast **red-eye round herring** (*Etrumeus teres*) was launched in 2007 and one experimental fishing permit was granted for a total of 100 tons of this species. The area fished is restricted to the coastal continental shelf edge between Durban and Richards Bay on the KwaZulu-Natal coast. The catch is largely sold for bait and is considered a lucrative fishery with the current value in 2007 as high as R3.00 per fish (C. van der Lingen, MCM, pers. comm.).

An experimental fishery for capture of **fish for aquarium trade** has been discussed and a possibility exists for further investigation of this.

CHAPTER 4

Shipping

Overview

South Africa is a maritime nation with several major ports. In global terms, the concentration of maritime traffic passing South Africa is not considered to be as high as those traversing areas such as the Panama Canal, Suez Canal or Strait of Hormuz (Gründlingh *et al.* 2006). The amount of cargo transported around the Cape of Good Hope is nevertheless significant, with ± 1 000 bulk carriers, 1 000 cargo vessels, 400 tankers, 1 000 container vessels and several smaller vessels passing by each year (www.environment.gov.za/soer/nsoer/index.htm: State of Environment Report 1999). This volume of shipping traffic warrants some level of regulation and control measures to ensure safe passage and prevent shipping accidents. In implementing Traffic Separation Schemes, South African maritime regulations stipulate that laden tankers should maintain a minimum distance of 20 nautical miles from the shore when westbound, and a minimum of 25 nautical miles from the shore when eastbound (South African Notice to Mariners 2007). Vessels are also recommended to steer a course allowing safe clearance of the Alphard Banks (35°S and 21°E) and the Mossgas (FA) production platform off the Mossel Bay area. Laden tankers on voyages solely between ports within South Africa's EEZ are exempt from the 20 and 25 nautical mile regulations; they are required, however, to maintain a distance of 10 nautical miles off prominent points of the coast, subject to weather, sea and current conditions (South African Notice to Mariners 2007).

Governance framework

Government has devolved responsibility for regulation of shipping activity to the South African Maritime Safety Authority (SAMSA), who are thus largely responsible for regulating shipping activity and any shipping-related incidents arising in South Africa's EEZ. SAMSA aims to ensure the safety of life and property at sea, prevent oil pollution by ships, and promote South Africa as a maritime nation through the implementation of the South African Maritime Safety Authority Act No. 5 of 1998 (South African Notice to Mariners 2007). SAMSA is responsible for providing advice to the Minister of Transport on maritime issues affecting South Africa, maintaining relevant legislation and policy, liaising with other government and international institutions, and managing pollution prevention and response capacity.

Other regulatory frameworks that allow for governance over the shipping industry include the MARPOL Protocol (with respect to shipping pollution), the Marine Traffic Act No. 2 of 1981, United Nations Convention and Law of the Sea, and regulations set by the International Maritime Organization, of which South Africa is a member (see Dumping of Waste section).

Biodiversity impacts

The shipping industry in South Africa has potential to impact on marine biodiversity through oil spills as a result of shipping accidents, discharge of ballast water and/or other waste materials and through ship strikes (collisions between vessels and large marine animals such as whales, basking sharks). Pollution reduces the quality of the ocean, making it less suitable for marine life (www.environment.gov.za/soer/nsoer/index.htm: State of Environment Report 1999). The discharge of ballast water from ships entering South African waters brings with it the risk of introducing invasive marine species. More than 22 million tons of ballast water are discharged in South African ports and harbours annually (www.mcm-deat.gov.za, May 2007). Invasive species can result in serious ecological and economic problems in marine environments, and a common result as the invasive species proliferate, is the severe depletion of biological diversity.

The Marine Environmental Protection Committee of the International Maritime Organization (IMO) has adopted a set of voluntary guidelines: *Guidelines for preventing the introduction of unwanted aquatic organisms and pathogens from ships' ballast water and sediment discharges*. IMO member states are urged to adopt the guidelines until better controls are passed as an annexure to the MARPOL Protocol. South Africa has not yet implemented these guidelines, but is working towards a strategy for the prevention of accidental invasions. Many countries have banned the practice of cleaning ships hulls at sea, where organisms are released into the wa-

ter. South Africa has not yet implemented such a ban. The Global Ballast Water Management Programme (GloBallast) has been operational in South Africa since 2000, implementing a systematic inventory and monitoring programme of all harbours and ports in the country. There is, however, no longer a local office. The GloBallast programme has also created awareness and mitigation measures to prevent introduction of invasive species (http://globallast.imo.org, May 2007).

Issues of conflict

While there is potential for conflict with other offshore marine users, the commercial shipping industry is not an extractive resource user of the marine environment and any conflict over area usage would be considered minimal. Commercial shipping activities generally observe fishing and mining vessels and avoid conflict over area usage where possible. Some instances of vessel collision have been known to occur but this is an infrequent event.

CHAPTER 5

Dumping of waste

Overview

The earliest reference to marine pollution in South Africa dates from 1811, when a British soldier stationed at the Cape of Good Hope recorded that 'all kinds of waste were conveyed to the shore of Table Bay and deposited in the surf, polluting it for lengthy periods' (Griffiths *et al*. 2004). During the Second World War, large-scale mortalities of marine birds, as a result of major oil slicks, caused considerable concern. Since then, catastrophic oil pollution has continued, largely unabated (Griffiths *et al*. 2004). In 1945, the South African Council for Scientific and Industrial Research (CSIR) was established and marks a turning point in pollution control in South Africa's marine environment (Griffiths *et al*. 2004). The CSIR initiated its first formal programme to study and combat marine pollution in 1973 and has continued with this mandate ever since (Griffiths *et al*. 2004). Marine pollution and the potential impacts thereof on the environment are certainly a justifiable cause for concern. Griffiths *et al*. (2004) states that thus far, pollution in the Benguela region as a whole has had a small impact on the environment, as compared to the exploitation of resources such as marine organisms, minerals and petroleum. Marine pollution in South Africa is considered low in comparison to many other industrialized countries (Griffiths *et al*. 2004).

Governance framework

South Africa is considered to have a good legislative framework providing protection to the marine environment from pollution. The South African Maritime Safety Authority (SAMSA) is the leading agent responsible for regulation of marine pollution in South Africa, with government having devolved responsibility to this authority through the South African Maritime Safety Authority Act No. 5 of 1998. South Africa is a member of the International Hydrographic Organization (IHO) and is signatory to several International Maritime Organization (IMO) protocols, those most pertinent to marine pollution being the London Convention 1972 and Protocol 1996 and the MARPOL 73/78 Protocol. The principle national legislative measures applicable to minimizing pollution in South Africa's EEZ, as implemented and enforced through SAMSA, are introduced below:

- **Marine Pollution (Control and Civil Liability) Act No. 6 of 1981** provides for protection of the marine environment from oil and other harmful substance pollution from ships. Operational oil discharges are restricted to less than 100 parts per million within the 200 nautical mile Prohibited Zone. This Act also introduces civil liability for discharges (accidental or intentional) resulting in pollution at sea.
- **Marine Pollution (Prevention of Pollution from Ships) Act No. 2 of 1986** provides for protection from pollution discharged from ships in terms of the International Convention for the Prevention of Pollution from Ships, 1973, amended by the MARPOL 73/78 Protocol.
- **Marine Pollution (Intervention) Act No. 64 of 1987** provides national implementation of two international conventions namely, the Intervention on the High Seas in cases of Oil Pollution Casualties and the Protocol Relating to Intervention on the High Seas in cases of Marine Pollution by Substances other than Oil, 1973.
- **International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC)** provides for steps to be taken to prepare for and respond to an oil pollution incident through on-board ship oil pollution emergency plans. Although South Africa is not a party to this convention, the *National Contingency Plan for the Prevention and Combating of Pollution from Ships* serves the requirements.
- **Dumping at Sea Control Act No. 73 of 1980** provides national implementation of the London Convention on the Prevention of Marine Pollution by dumping of wastes and other matter, 1972. It provides for the control of dumping various substances and structures at sea and introduces the precautionary and 'polluter pays' principles. Schedule 1 of the Act refers to 'Prohibited Substances' which include organo-halogens, mercury, persistent plastics and high-level radioactive waste. Schedule 2 of the Act refers to 'Restricted Substances' and includes arsenic, lead, cyanides, fluorides, scrap metal and ammunition.

In addition to the existing legislation to control pollution of the marine environment, the Pollution Subdirectorate at MCM has applied to the International Maritime Organization for declaration of a certain marine area around South Africa as a Special Area. A Special Area designation will assist in controlling the impact of illegal and/or irregular oil discharges from international vessels in South Africa's marine environment. The proposed Special Area incorporates the continental shelf from the mouth of the Spoeg River in the west to immediately east of the Great Fish River mouth in the east extending out to the continental shelf break at the 500 m isobath. The area encompasses the whole of the continental shelf region known as the Agulhas Bank as well as the southern and central portion of the southern Benguela upwelling ecosystem. Declaration of this Special Area will assist in reducing oil pollution risks by restricting the allowed concentrations and quantities of discharges into the marine environment in the declared area. Special Area designation is hoped to significantly assist South Africa in meeting its national and international obligations for environmental protection and pollution reduction in the region.

The Department of Water Affairs and Forestry are responsible for management of all waste water emanating from land-based sources, transported into the sea (Oelofse *et al.* 2004). Any organization wishing to dispose of any substance, including dredging sediment from ports and harbours, must apply for a permit to do so from the Department of Environmental Affairs and Tourism: branch of Marine and Coastal Management. The Department issues a permit on an individual basis, stipulating the precise quantity and location where the spoil should be dumped. The majority of such permit applications are for dredging maintenance operations for harbours and ports and dredge spoils are usually dumped within the vicinity of the area being dredged.

Biodiversity impacts

Pollution is considered to be the second biggest threat to South Africa's marine environment, after extraction of marine living resources (i.e. fishing, Lombard *et al.* 2004). There are several sources of ocean pollution, including land-based (e.g. sewage outlet pipes, storm water runoff), river runoff (nutrient loading, heavy metals), atmospheric (CO_2 from burning fossil fuels) and marine-based (www.ewt.org.za, May 2007). Approximately 80 % of marine pollution originates from land-based sources such as marine outfalls and pipelines (www.mcm-deat.gov.za, May 2007). Most sources of pollution ultimately impact on the oceans and coastal zones. However, for the purposes of this report and the objectives of the Offshore Marine Protected Areas project, this summary will largely concentrate on marine pollution impacting on offshore regions. The National Spatial Biodiversity Assessment Project (Sink 2004, Appendix 2) identified nine categories of pollution that threaten marine biodiversity including oil pollution, shipping (noise pollution), dredge disposals, plastics pollution and ghost fishing. Oil pollution is considered to be the most severe and extensive threat to marine environments, and one that is ongoing, as South Africa's EEZ hosts a substantial amount of maritime traffic and serves as an important shipping route (Sink 2004; Gründlingh *et al.* 2006). Catastrophic oil pollution has intermittently impacted marine biodiversity in the past 50 years, although more recently, improved legislation and mitigation measures, at both national and international levels, have reduced such incidents (Sink 2004). Oil spills impact particularly severely on marine birds and mammals.

There is some concern that high densities of shipping traffic and the resultant marine noise pollution, impacts on marine organisms, specifically marine mammals, such as whales and dolphins that rely on sound frequencies for communication (Sink 2004). Along with the increase in shipping activity comes the threat of invasive marine species, which can be introduced to the marine environment through ships discharging ballast water, when entering a port. As much as 22 million tons of ballast water is discharged annually in South Africa's ports or harbours, presenting a significant possibility of introducing foreign invasive species (www.mcm-deat.gov.za, May 2007).

The dumping of dredged materials at sea is controlled by the DEAT MCM Pollution Subdirectorate, under local legislation (Dumping at Sea Control Act No. 73 of 1980) and the international London Convention of 1972. An average of 10 permits are issued each year allowing dredged materials to be dumped at specified locations, mostly near ports or harbours (S.Pheeha, MCM, pers. comm.). The Pollution Subdirectorate is responsible for screening applications, issuing permits, establishing the location of dump sites, implementing environmental monitoring programmes

and monitoring the nature of the waste being dumped (www.mcm-deat.gov.za, May 2007). Dumping of such dredged materials can threaten subtidal communities and biodiversity through smothering effects, toxicity of suspended sediments and increased turbidity (Lane & Carter 1999).

Discards of plastic waste matter constitute a large proportion of visible litter in South Africa's marine environment. Plastic materials discarded at sea pose a significant threat to many marine animals through accidental consumption thereof or entanglement leading to injury or drowning. Animals particularly at risk are top predators such as dolphins, whales, seals, turtles and sea birds (www.ewt.org.za, May 2007). Discarded or lost fishing gear results in 'ghost fishing' where fishing nets, traps and pots drift with ocean currents entangling and trapping marine species. Heavily laden fishing gear sinks to the ocean floor, where the catch decomposes, attracting scavengers, until the gear is sufficiently light to continue drifting with the current, trapping further fish. This ongoing cycle of destruction continues for the life span of the fishing gear and the negative impacts thereof on marine biodiversity are difficult to measure.

The impacts that these various pollutants have on marine ecosystems depends on the chemical and physical characteristics of the particular pollutant (Moldan 1989). Chemical characteristics to be taken into account include the persistence/degradability, accumulation in biological systems or sediments, availability to marine organisms, the likelihood of transformation to more harmful compounds, adverse effects on oxygen balance and general toxicity levels (Moldan 1989).

Issues of conflict

There have been instances where toxic waste dumped at sea has been brought to the surface by trawlers. A drum of mustard gas was recently trawled up on the Agulhas Bank and posed a significant health hazard to the crew of the vessel (Peter Simms pers. comm.).

Sediment plumes and turbidity of water may result in a short-term decrease in fish abundance in the immediate area, impacting on fishing activities.

CHAPTER 6

Submarine cables

Overview

Services carried through undersea cables include international telecommunications, emails, internet traffic and television services. Undersea cables are an essential component in South Africa's strategic mix of satellite and cable telecommunication links with the rest of the world. Submarine cables provide faster data transfer than satellite systems (www.safe-sat3.co.za, May 2007). The speed of data transmission along the cable is the same as satellite systems, but the distance data must travel is much shorter through a submarine cable. Geostationary satellites for telecommunications are placed some 37 000 km above the earth, which means transmissions travel almost 74 000 km, from the earth to the satellite and back to earth. Cables also have shorter hearing delays, higher quality of data transmission and lower costs (www.safe-sat3.co.za, May 2007). Furthermore, submarine cable systems are not affected by bad weather. This is important for connections between countries, such as Mauritius and Reunion that lose international connectivity when they are forced to suspend satellite transmissions during rough storms (www.safe-sat3.co.za, May 2007).

South Africa has one defunct and three active submarine cables that pass through the EEZ (Figure 4 Source: http://eassy.org, May 2007):

- SAT 1. This is a defunct Telkom cable that comes ashore at Melkbosstrand along with SAT 2. This cable is currently on the seabed but it has been sold and will be recovered (J.P. Thomas, Telkom, pers. comm.).
- SAT 2. This is an active Telkom fibre-optic cable that crosses the Atlantic and connects South Africa to western Europe via the SAT 3 cable at the Canary Islands.
- SAT 3/West African Submarine Cable (WASC). This active cable, installed in 2001, runs from Melkbosstrand to Mtunzini and connects to the SAFE cable.
- South African/Far East (SAFE). As its name suggests, the SAFE Cable provides a connection between South Africa and the Far East. This cable has landing points at Melkbosstrand and Mtunzini in South Africa.

South Africa initiated negotiations to develop a submarine cable system in 1964. The SAT 1 cable was planned as a system capable of transmitting 360 simultaneous telephone calls! SAT 1 was replaced by SAT 2 in 1993 to work in tandem with the existing satellite system. SAT 2 can cope with 5 360 simultaneous transmissions in several different forms, including voice, television, and data transfer. At the time it was planned, SAT 2 was expected to cater for telecommunication requirements for the next 20 years. However, demand soon escalated to the point where SAT 2 was approaching capacity. The SAT 3/WASC-SAFE network provides an underwater global information highway for the southern hemisphere. It has the potential to access 90 % of Africa's existing sub-Saharan telephone market in which 72 % of the sub-Saharan population lives (www.safe-sat3.co.za, May 2007). A fourth network termed the East African Submarine Cable System (EASSY) is planned to complete the optic fibre ring around Africa in conjunction with other optic fibre submarine cable systems (SAFE, SEA-ME-WE 3 and 4, SAT 3). This cable would allow several countries in East Africa access to broadband and is considered a critical element in Africa's economic and social development. The cable would run from Mtunzini northwards and would connect with the SAFE and SAT 3 links (http://eassy.org, www.eafricacommission.org, May 2007).

SAT 1 and SAT 2 from western Europe are laid on the sea floor following approximately the 3 000 m isobath. They run up the Cape Canyon to land at Melkbosstrand, several kilometres north of Cape Town. The SAT 3 cable links Portugal to South Africa with eight African landing points along the way while the SAFE cable connects Cape Town to India and Malaysia via Mauritius. These two cables constitute 28 800 km of cable. A further 25 landlocked African countries can link into the SAT 3/SAFE network through terrestrial and satellite facilities, extending its many benefits into the heart of the continent. From Portugal, onward connectivity links sub-Saharan Africa with the Americas and the Middle East, and from Malaysia, onward communication is provided to Australia and the Asian Pacific Rim.

Cables are laid either on the seabed or buried just below the sea floor. The South African sections of the cables lie on the sea floor and are

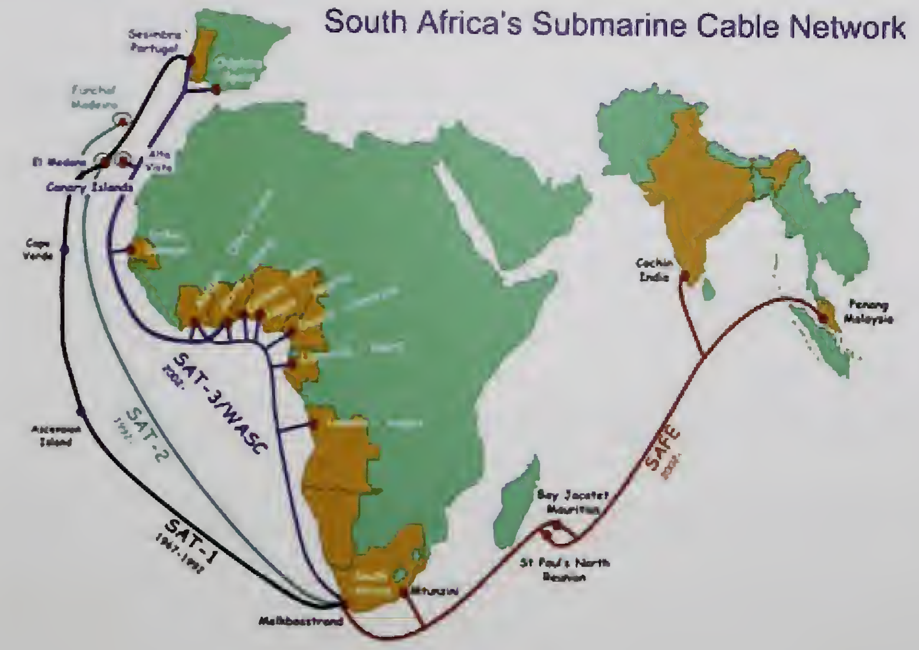

FIGURE 4.—Layout of submarine cables servicing South Africa (source: http://eassy.org).

not buried. The greatest cable depth is 6 000 m (J.P Thomas, Telkom, pers. comm.). Burying these cables can involve the use of a submarine cable plough to clear the seabed or a pre-lay grapnel to clear the cable route (MENZ 2005). Most cables are laid using a specialized cable installation ship. To avoid disruption to the line, specifically where it has not been buried, an activity exclusion zone of one nautical mile each side of the cable is applicable in which no anchoring is permitted (CCA & CMS 2001). It was planned that where sea floor conditions permit, the SAT 3 cable would be buried 0.7 m below the sea floor from the landing points to 1 000 m water depth.

Cable installment represents a very expensive capital investment in the cable and associated electronic infrastructure. This is recovered by low cost, high volume returns. Cable failure carries significant economic risk. All submarine canyons are indicated on SAN navigational charts and marked with a warning. In the Western Cape, SAT 2 and SAT 3 cables are monitored at the Melkbosstrand Cable Terminal Station where a 24-hour, computerized radar surveillance system monitors all shipping activities near the 'anchoring and trawling prohibited zone' of one nautical mile on either side of the submarine cables. The International Cable Protection Committee also promotes the safeguarding of submarine cables. The committee, which has members from more than 44 countries, is a forum for the exchange of technical and legal information about submarine cable protection methods.

Value

Submarine cables are usually owned by consortia. The cost of the new EASSY cable project (a system from South Africa to Djibouti), is estimated at US$ 200 million (US$ 170 million for the System Supply and US $30 million for project management). Telkom initiated the US$ 639 million, three-year process of laying the cable and setting up landing points. Telkom contributed around US$ 85 million to the project, but owns a proportionally larger percentage (16 %) of the consortium that owns the cable, and will have access to a third of its capacity. The economic benefits of submarine cables are difficult to quantify but the communications links these networks provide are critical to South Africa's modern economy.

The last submarine cable failure in South Africa took place in 1993 when a dragging ship's anchor broke a cable on the west coast. As no cable laying ship was present in South Africa at that time, considerable expenses were

incurred, litigation took place and the vessel owner had to cover the costs of re-routing data via satellite and repairing the cable (J.P. Thomas, Telkom, pers. comm.).

Biodiversity impacts

Laying submarine cables can cause localized disturbance of marine sediments, benthic macrofauna and fish (MENZ 2005). The cables on South Africa's sea floor are currently not buried. The cable office was not aware of any environmental authorization procedures for laying cables in South Africa's EEZ.

Issues of conflict

Submarine cables can be damaged by other ocean users. Fishing and anchoring can damage cables particularly when skippers are unaware of the location of cables, anchors drag within prohibited zones, fishing accessories such as otter boards and attachments are poorly maintained or trawl nets snag on broken cable armour-wires (www.safe-sat3.co.za, May 2007). The stability of a vessel attempting to lift a cable can be affected and raising cables can damage them. Cables can pose serious safety hazards (e.g. if cut when under tension) when handled by untrained people. Modern cables can also carry high DC voltage. Anchoring and trawling are prohibited within one nautical mile of the SAT 2, SAT 3 and SAFE submarine cables. Some demersal trawl skippers report that they trawl over these cables by lifting their gear.

CHAPTER 7

Naval activities

Naval military practice and exercises are necessary for the safe, efficient and effective operations of the South African Navy (SAN). The nature of services required by the South African Navy imply that military practice and exercises are required to be carried out in various areas of the marine environment.

These activities generally include weapons test firing, using projecting rocks at sea as targets, sound testing, demolition areas, proof range testing, air to air weapon testing and air to ground weapon testing (South African Notice to Mariners 2007).

Table 7.1 in South African Notice to Mariners (2007)–Summary of practice and exercise areas for Naval activities in South Africa, 2007

Region	Name and area	Type of naval activity
Western Cape, west coast	PAPENDORP Doringbaai	Anti-aircraft weapons
	LANGEBAAN ROAD RANGE Saldanha	Air to air weapons
	SALDANHA Saldanha	Air to air weapons
	NORTH HEAD Saldanha	Weapons
	TOOTH ROCK Saldanha Circle	Air to ground weapons Jacobs Reef bombing Test firing of illuminants
Western Cape, Cape Point	WESTERN CAPE Cape Point	Naval exercises
	BELLOWS ROCK Cape Point	Naval weapons (rock as target)
Western Cape, False Bay	GARDEN NO. 1 False Bay	Sound testing range
	GARDEN NO. 2 False Bay	Sound testing range
	PROOF NORTH False Bay	Proof range
	PROOF SOUTH False Bay	Proof range
	LOWER NORTH False Bay	Weapons testing
	STRANDFONTEIN False Bay	Proof range
	SWARTKLIP False Bay	Proof range
	MACASSAR False Bay	Anti-aircraft weapons
	SIMON'S TOWN False Bay	Shallow water demolition range
	SIMON'S TOWN False Bay	Deep-water demolition range
Southern Cape, Cape Agulhas	DE HOOP (POTBERG) Cape Agulhas	Weapons testing range
Eastern Cape, Port Elizabeth	CAPE RECIFE Port Elizabeth	Rifle range
Natal, Durban	DURBAN Durban	Naval weapons
Northern Natal, St Lucia	ST LUCIA St Lucia	Naval weapons

International chart specifications require that military practice and exercise areas be removed from navigational charts (South African Notice to Mariners 2007). The areas are demarcated on the PEXASAN chart series, and the South African National Hydrographic Office (SANHO-21) document, Sailing Directions Volume I, contains relevant information on range safety warning signals and safety of navigation in military exercise areas (South African Notice to Mariners 2007). Whenever military exercises take place in South African waters, coastal navigation warnings are broadcast, issuing details thereof, except in the vicinity of Swartklip, False Bay (34°04'.5 S, 18°41'.2 E), where test firing of minor illuminants, with or without parachutes, frequently occur without such warnings (South African Notice to Mariners 2007).

Practice and exercise areas for naval activities in South Africa are published in the South African Notice to Mariners annually with a summary of general areas provided in Table 7.1 (South African Notice to Mariners 2007). A comprehensive list of areas published in 2007, with detailed co-ordinates, is provided as Annexure A to this report.

The relatively small-scale and confined area of naval activities are not considered likely to have severe impacts on marine biodiversity. There is concern about weapons testing or target practice in existing MPAs (e.g. at Bellows Rock in the Table Mountain National Park MPA).

Some incidences of conflict have been reported between the navy and coastal fishing operations—however, these are largely restricted to inshore coastal areas. There have been some reports of conflict between the tuna pole sector and naval activities in the Cape Canyon region.

CHAPTER 8

Scientific research

Overview

A fascination with the oceans and the creatures therein has formed a part of South Africa's history long before the importance of scientific research was evident. The natives of South Africa's coast had vast knowledge of the sea and its resources, many of whom relied on its harvest for survival. The earliest known written records of marine observations, with extracts from diaries and letters often detailing such events, occurred after the arrival of European explorers and settlers (Brown 1997). Simon van der Stel diarized an outbreak of red tide in Table Bay in the 1680s and by 1811 the first concerns of marine pollution in the Bay were noted. Many explorers visited the Cape and, although mostly interested in terrestrial plants and animals, some records of marine species were made with some specimens even making their way back to Europe to be described by experts there (Brown 1997). Several marine exploratory expeditions called in at the Cape, with the British vessel, *Challenger*, conducting the first exploration of South African waters from the coast to depths beyond the continental shelf, measuring oceanographic and biological aspects of these waters (Brown 1997). By the end of the 19th century, a fair amount of knowledge of South Africa's oceans had accumulated, but this information was unsystematic and fragmentary (Brown 1997). The appointment of Dr John Dow Fisher Gilchrist, as the first marine biologist of the Department of Agriculture of the Cape Colony in 1895, was the start of dedicated marine research in South Africa (Brown 1997).

The first research vessel dedicated to exploring the Cape waters was that of the *Pieter Faure*, a trawler brought out from Scotland by Gilchrist in 1897 (Brown 1997). These early voyages and discoveries are documented in the Reports of the Marine Biologist (1896–1900) and the Reports of the Government Biologist (1901–1908). Gilchrist was soon requested to expand his explorations into Natal waters too, which he dutifully did. Gilchrist was a general scientist and took great interest in every aspect of the ocean and its numerous species, extending his research to encompass not only species of commercial value but all species that appeared in his trawl nets, including benthic fauna. The government built him South Africa's first aquarium at St James in the western Cape in 1902, which housed not only a working laboratory, but also a display open to the public. The building served its purpose well but was eventually closed in 1936 and later demolished. The foundations may still be seen on the seaward side of the railway line, some 50 m south of the present St James bathing boxes (Brown 1997).

Early marine research in South Africa was disrupted during the First World War when the *Pieter Faure* was commandeered by the Royal Navy (Brown 1997). Gilchrist, however, used this period to publish much of his research, mostly on fish, but also on the reproduction of *Phoronopsis*, a new species of *Branchiostoma*, hemichordates and several other genera and species (Brown 1997). In the 1920s, Gilchrist acquired a converted whaling vessel, the *Pickle*, from which he continued his marine surveys, extending into Mozambique and Namibia (Brown 1997). Gilchrist, teamed with Keppel Barnard, the taxonomist at the South African Museum, continued his marine research until his death in 1926 (Brown 1997). Gilchrist was undoubtedly the pioneer of southern African marine research and considered a truly great scientist (Brown 1997).

Scientific research in southern African waters continued to grow and expand with frequent visits from international vessels and marine scientists. In 1950, South Africa commissioned the F.R.S. *Africana II*, a state-of-the-art scientific research vessel, dedicated to conducting research in South Africa (Lutjeharms & Shannon 1997). In 1966, the University of Cape Town commissioned its own custom-designed research vessel, the *Thomas B. Davie*, while the CSIR built the coastal research vessel the *Meiring Naudé*. With the growing fleet of research vessels, South Africa's offshore research continued to expand into ever increasingly unexplored waters with continual deployment of oceanographic equipment and sampling, largely through trawling, providing much sought-after knowledge of our oceans.

A multitude of scientific research cruises continue to take place each year in South Africa, providing new samples, species and information from the depths of the oceans. Scientific sampling, bioprospecting and deployment

of a vast array of high-tech oceanographic equipment contribute to acquiring necessary information, essential for sound management of our marine resources. It is, however, considered essential that each of these activities have clear objectives with respect to their sampling design, are well managed and should not threaten marine biodiversity.

Bioprospecting refers to the systematic search for potentially useful biochemical compounds. Organisms are screened for compounds that may be used in medicine (e.g. the cure for cancer), traditional healing (e.g. fertility enhancers) and industrial applications (e.g. bioadhesives). A few pharmaceutical companies have bioprospected in South Africa's marine territory and some of these collection programmes have had scientific benefits. Collections off the eastern Cape, for example, have led to the discovery of ecological relationships and improved taxonomic records (Attwood *et al.* 2000). The marine bioprospecting industry is poorly regulated in South Africa. Permits are required from Marine and Coastal Management.

Biodiversity impacts

Collectors may threaten rare taxa such as the coelacanth, *Latimeria chalumnae* (Attwood *et al.* 2000). Coelacanths are specially protected in South Africa and a management plan exists for the population in the Greater St Lucia Wetland Park. No reports on the biodiversity impacts of bioprospecting were found. Research focused on stock assessments for fisheries, where the same method as the relevant fishery is employed (e.g. trawling), can be expected to have similar impacts as those fisheries (e.g. research trawls). Scientists would argue that these are of a smaller scale and thus inflict comparatively less impact. However, research trawls can and do take place in areas where fisheries cannot operate and these may have additional biodiversity impacts. Much of the offshore research is hampered by a lack of protected offshore control areas which are essential in assessing any impacts of offshore activities, as noted by Attwood *et al.* 2000. The impacts of scientific research (sampling, bioprospecting and equipment deployment) on offshore biodiversity are currently not considered to be of substantial concern, although caution should always be exercised in the extent of impact inflicted during each investigation, especially in areas that have not previously been accessible to either commercial activities or research.

Issues of conflict

There are seldom critical conflict issues between scientific research and other offshore users, with a healthy respect having developed between the sectors. Nonetheless, the continued pursuit for representative, unexploited marine areas for comparative scientific research may pose a potential for future conflict between research and offshore users.

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Annexure A

Practice and exercise areas for Naval activities in South Africa, 2007 (South African Notice to Mariners 2007)

Name and area	Type	Latitude & longitude
PAPENDORP Doringbaai Closed area	Anti-aircraft weapons	31°42'.4 18°11'.7 31°37'.5 18°05'.0 31°44'.0 18°02'.0 31°50'.0 18°06'.0 31°52'.0 18°13'.5 31°43'.5 18°12'.5 31°42'.4 18°11'.7
LANGEBAAN ROAD RANGE Saldanha Closed area	Air to air weapons	32°45'.0 17°40'.0 32°45'.0 17°49'.0 32°58'.0 17°55'.0 33°06'.0 17°56'.0 33°08'.2 17°58'.0 33°14'.9 18°05'.8 33°21'.0 18°09'.0 33°29'.0 18°04'.5 33°27'.0 17°59'.0 33°00'.0 17°40'.0 32°45'.0 17°40'.0
SALDANHA Saldanha Closed area	Air to air weapons	32°45'.0 17°49'.0 33°26'.0 18°05'.0 33°29'.0 17°54'.0 32°48'.0 17°38'.0 32°45'.0 17°49'.0
NORTH HEAD Saldanha Closed area	Weapons	33°03'.01 17°54' 33°03'.01 17°53'.23 33°00'.70 17°53'.13 33°01'.23 17°54'.25 33°03'.01 17°54'.51
TOOTH ROCK Saldanha Circle	Air to ground weapons, Jacobs Reef bombing. Test firing of illuminants	radius 3.5 nautical miles centred at 32°59'.0 S, 17°51'.0 E
WESTERN CAPE Cape Point Closed area	Naval exercises	34°15'.0 18°23'.0 34°24'.0 17°44'.5 Arc of circle, radius 50 nautical miles, centred at 33°58'.1 S, 18°36'.0 E from 34°24'.0 S,18°36'.0 E to 17°44'.5 E 34°44'.0 S, 19°00'.0 E. 34°30'.0 19°00'.0. 34°30'.0 18°48'.0 34°15'.0 18°48'.0 34°15'.0 18°28'.3 34°15'.0 18°23'.0
BELLOWS ROCK Cape Point	Naval weapons (rock as target)	34°23'.3 18°29'.6
GARDEN NO. 1 False Bay Closed area	Sound testing range	34°08'.60 18°27'.08 34°08'.62 18°28'.25 34°09'.60 18°28'.22 34°09'.57 18°27'.05 34°08'.60 18°27'.08

GARDEN NO. 2 False Bay Closed area	Sound testing range	34°10'.86 18°27'.11 34°10'.88 18°27'.14 34°10'.88 18°27'.01 34°10'.90 18°27'.12 34°10'.86 18°27'.11
PROOF NORTH False Bay	Proof range	2.2 nautical miles (4 000 m) from 34°11'.13 S, 18°26'.32 E between bearings 235° and 243°
PROOF SOUTH False Bay	Proof range	8.5 nautical miles (15 500 m) from 34°11'.13 S, 18°26'.32 E between bearings 265° and 275°
LOWER NORTH False Bay	Weapons testing	11 nautical miles (20 384 m) from 34°10'.50 S, 18°25'.75 E between bearings 254° and 283°
STRANDFONTEIN False Bay Closed area	Proof range	34°05'.50 18°32'.00 34°04'.50 18°41'.50 34°05'.50 18°47'.75 34°15'.00 18°44'.00 34°16'.50 18°31'.50 34°05'.50 18°32'.00
SWARTKLIP False Bay	Proof range	34°04'.40 18°42'.10 34°05'.00 18°41'.00 34°18'.00 18°44'.00 34°18'.00 18°48'.00 34°05'.00 18°45'.00 34°04'.50 18°43'.90
MACASSAR False Bay	Anti-aircraft weapons	8 nautical miles (14 830 m) from 34°04'.4 S, 18°42'.2 E between bearings 314°20' and 046°20'
SIMON'S TOWN False Bay Closed area	Shallow water demolition range	34°11'.266 18°26'.650 34°11'.317 18°26'.991 34°11'.417 18°26'.940 34°11'.383 18°26'.700 34°11'.266 18°26'.650
SIMON'S TOWN False Bay Closed area	Deep-water demolition range	34°11'.3 18°30'.0 34°11'.5 18°32'.0 34°10'.0 18°32'.0 Arc of circle, radius 1 nautical mile, centred at 34°09'.0 S, 18°32'.0 E from 34°10'.0 S, 18°32'.0 E to 34°09'.25 S, 18°30.'85 E. 34°09'.5 18°30'.0 34°11'.3 18°30'.0
DE HOOP (POTBERG) Cape Agulhas Closed area	Weapons testing range	Sea area at right angles to coast for distance of 500 m from 34°30'.47 S, 20°26'.93 E to the point 34°35'.08 S, 20°21'.83 E and sea area that runs at right angles from shore for distance of 5 000 m (5 km) from the latter point to 34°38'03" S, 20°16'10" E'

CAPE RECIFE Port Elizabeth Closed area	Rifle range	34°01'.0 25°39'.0 34°01'.0 25°40'.0 34°03'.0 25°40'.0 34°03'.0 25°39'.0
DURBAN Durban Closed area	Naval weapons	29°51'.90 31°03'.87 29°47'.60 31°20'.40 30°00'.00 31°18'.80 30°08'.20 31°07'.70 29°53'.75 31°02'.48 29°51'.90 31°03'.87
ST LUCIA St Lucia Closed area	Naval weapons	27°42'.95 32°37'.75 27°40'.33 32°31'.00 27°52'.58 32°24'.20 27°55'.58 32°24'.50 28°03'.83 32°23'.00 28°05'.00 32°27'.82 28°05'.50 32°29'.63 28°06'.67 32°33'.58 28°07'.33 32°48'.00 27°38'.00 32°54'.00 27°38'.00 32°45'.75 27°42'.95 32°37'.75

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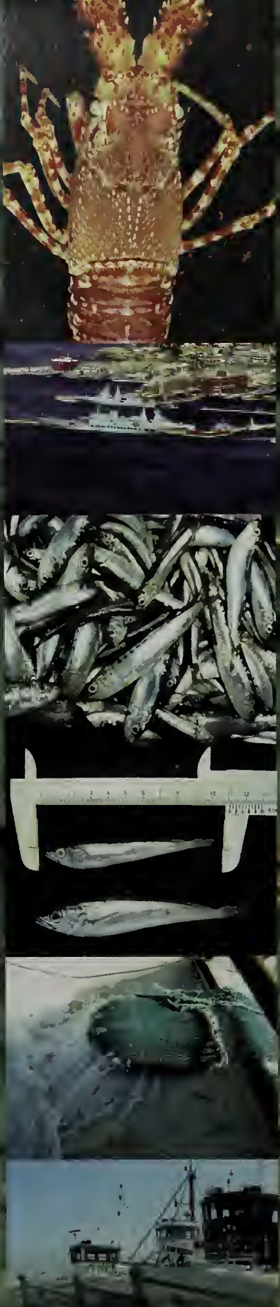

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